The AUTOMATIC ELECTRIC Technical Journal

magazine devoted to progress in communication engineering

In this issue:

THE BRITISH POST OFFICE AND STROWGER AUTOMATIC

THE EXPANDING FIELD OF APPLICATION FOR STROWGER AUTOMATIC TOLL TICKETING . . *J. E. Ostline*

TOLL ANSWERING DELAYS AND THEIR MEASUREMENT . . . . *Imre Molnar*

POWER EQUIPMENT IN STROWGER AUTOMATIC TELEPHONE EXCHANGES . . . . *N. Salvesen*

THE TYPE 48 COMMUNITY AUTOMATIC EXCHANGE . . . . *C. Christensen*

UNIVERSITY OF MICHIGAN
AUG 10 1951
ENGINEERING LIBRARY

July, 1951

Issued by

AUTOMATIC ELECTRIC COMPANY
Chicago, U. S. A.
and affiliated companies

Contributors to this issue

JOHN E. OSTLINE, a native of Sweden, came to the United States in 1905, and soon thereafter became engaged in the construction, maintenance, and operation of various telephone properties. Later he took up traffic engineering, specializing in call indicator, AB toll, and other facilities relating to multi-office networks. He joined Automatic Electric Company in 1921, and then spent several years in England assisting in the conversion of the London telephone system to automatic operation using the Strowger "Director". Since his return to Chicago he has made many other important contributions to automatic switching in metropolitan areas, a notable example being the development of automatic toll ticketing. He is a Fellow of the American Institute of Electrical Engineers.

IMRE MOLNAR received his first experience in telephone work in the installation of major projects in Europe during the period 1921-25. After graduating in Communication Engineering (Berlin, 1930), he became associated with the Automatic Electric Group; he was first engaged in circuit design, transmission engineering and installation, and served also as resident engineer in several countries abroad. Between 1937 and 1943 he was employed by Automatic Electric Company as a circuit design specialist. Since 1943, in his present position as Project Engineer, he has been concerned with general developments in the Automatic Electric Laboratories. During the summer of 1950, he received the degree of Doctor of Philosophy in Electrical Engineering from Northwestern University, Evanston, Illinois, his thesis being based on his long study of telephone toll traffic.

N. SALVESEN is a native of Norway, where he attended a school of mechanical engineering. Coming to Chicago in 1903, he entered the employ of Automatic Electric Company and was assigned to the telephone department. His flair for design led him to seek a technical position, and in 1909 he was assigned to the Drafting Department as mechanical engineer. Since 1920 he has been a member of the equipment engineering staff, and is now engaged in a supervisory capacity in connection with the planning and engineering of automatic exchange networks.

C. CHRISTENSEN is a native of Denmark, where he attended Westerdahls College and Odense Technical College. After coming to the United States in 1912 he gained experience in the telephone industry as a telephone equipment designer. In 1928 he entered the employ of Automatic Electric Company and was assigned to the drafting department as a cable designer, later becoming a supervisor in the same department. In 1939 Mr. Christensen was transferred to the engineering department where he has had varied experience in equipment design and exchange engineering. Because of the wide knowledge he had gained in telephone company requirements he was transferred to the "customer" engineering department in 1948 where he is now engaged in planning and engineering automatic exchange networks.

Copyright 1951
By Automatic Electric Company

The AUTOMATIC ELECTRIC TECHNICAL JOURNAL

A Magazine Devoted to Progress in Communication Engineering

Issued By

AUTOMATIC ELECTRIC COMPANY

and affiliated companies

Address all communications to: 1033 W. Van Buren Street, Chicago 7, U.S.A.

EDITORIAL ADVISORY BOARD

K. W. GRAYBILL — C. F. FFOLLIOTT — A. E. WOODRUFF — C. J. DIEHL — F. L. KAHN

R. STEHLIK, Antwerp, Belgium — D. GALASSI, Milan, Italy — W. W. ASHWORTH, Brockville, Canada — C. R. HUGHES, Toronto, Canada

L. DEROISY, Antwerp, Belgium — C. MIGLIASSO, Milan, Italy — J. S. WADDINGTON, Brockville, Canada

H. E. CLAPHAM, *Editor*

July, 1951 — Price: 50 cents per copy — Vol. 3, No. 1

THE BRITISH POST OFFICE AND STROWGER AUTOMATIC

Editor's Note—On the occasion of his inauguration as President of the Institution of Electrical Engineers on October 5, 1950, Sir Archibald J. Gill, Engineer-in-Chief of the British Post Office, gave a brief summary of progress in the use of automatic telephones in the United Kingdom since the Post Office, in 1925, announced its adoption of Strowger equipment as standard for all exchanges.

The Institution has graciously extended permission for us to reproduce in this Journal the remarks made by Sir Archibald on that subject, and we gratefully acknowledge this courtesy. His review of the remarkable growth of automatic switching in the United Kingdom constitutes a well deserved tribute to the vigor and determination with which the Post Office has pursued its conversion program through one of the most difficult and trying periods in the world's history, and in particular to the vision and zeal of the late Sir Thomas Purves, former Engineer-in-Chief of the British Post Office under whose administration the early stages of that program were so effectively carried out.

The success of the British Post Office in extending its use of Strowger equipment so widely is naturally a cause for considerable pride also to Automatic Electric Company. It is a matter of common knowledge that the Strowger system was originated and first brought to the stage of technical and commercial success by that company. Further, as Sir Thomas Purves pointed out in his address in 1925 ("The Post Office and Automatic Telephones"), the Strowger "Director", which was one of the important developments which influenced the Post Office in its adoption of Strowger equipment for the Greater London area, was also a development of the Automatic Electric engineering staff.

The standardization by the British Post Office on the Strowger System, and the predominant use of this equipment by Bell and Independent companies in the United States and by the greater proportion of private companies and governmental administrations in other countries represent grati-

fying confirmation of the soundness and economy of Strowger techniques.

The excerpt from Sir Archibald J. Gill's inaugural address follows:

"On the subject of switching, many of you will remember that Sir Thomas Purves in his address in 1929 gave some interesting information on the progress that had then been made in the conversion of the telephone service to automatic working. This progress has continued, though slowed down to some extent by the war and the subsequent restriction of capital expenditure. At that time 21 large exchanges had been brought into service in London and the provision of 26 further exchanges was then in hand. At that time also there were 163 automatic exchanges in operation in urban areas having a capacity of about 500,000 stations, and planning and construction of 126 further exchanges was in hand. There were also 487 manual exchanges having a capacity exceeding 300 lines, and 3,790 smaller exchanges serving about 1½ million stations. Thus about 25% of the total stations were on automatic exchanges. The growth of the system and the change-over to automatic working has continued, and the position today is as follows:

"There are 182 automatic exchanges in operation in London, 134 of them being of the large director-exchange type; in the provinces there are a further 3,919 automatic exchanges; the London and provincial automatic exchanges serving a total of 3.6 million stations. Although the number of stations served by manual exchanges remains at approximately 1½ million, the stations served by automatic exchanges now represent 70% of the total.

"In recent years there has been a steady change-over of small rural exchanges to automatic working. The small manual exchanges which they replaced were generally housed in private premises—the homes of caretakers. A change in caretaker, due to death or other reasons, therefore often involved a removal of the exchange, sometimes at short notice, and often it became difficult or impossible to find a new home for the equipment or a person willing to undertake the duties. In order to cope with this difficulty and other emergencies the Post Office has provided a number of mobile automatic exchanges which can be run on to a piece of vacant ground and coupled up very rapidly to give service until such time as it is possible to provide a permanent installation.

"In 1929 Sir Thomas Purves also reported that the director system, which had been specially evolved for the service of London, was realizing in practice the hopes that had been founded on it. Five years prior to this Sir Thomas had been called on to decide between the merits of the various existing automatic systems for standardization by the Post Office, and in a paper read before The Institution in 1925 he explained why he had decided to adopt the Strowger step-by-step system generally throughout the country with director working for the largest cities. In this paper he stated, *'I am far from asserting that the London system will in 20 years' time necessarily stand as a model for the world to copy, but I am confident that the adoption of the step-by-step system, with the notable addition of the automatic director and other technical developments as worked out for London, represents the most practically suitable and effective way in which the telephonic needs of the next generation can be met in that great and important area.'* Sir Thomas had in after years the satisfaction of knowing that his choice had been a wise one and that the system he had adopted fulfilled every demand made upon it. It is true that in the interval other systems have been evolved—some suited to large cities and others to smaller communities. Some of the newer systems have particular advantages such as greater availability on their switches or speedier operation. None, however, has the simplicity and the universality of the step-by-step system, which allows the same components and the same circuits to be used in the smallest and the largest exchanges. Thus it is probable that if a similar decision had to be made today the choice would be the same as it was 25 years ago.

"Since 1945, teams of experts from this country have visited all the countries in the world where telephone development has been taking place. Much useful information has been acquired as a result of these visits, but nothing we have seen has suggested that the step-by-step system is obsolete or even obsolescent. Most of the later developments, such as, for example, automatic ticketing or automatic accounting, can be added quite readily to the existing system should this be desired. In fact it is becoming obvious that there would be no gain now, and it is extremely doubtful whether there would be any gain in the future, in changing the present basic system for any other electro-mechanical system, and that the present system will meet all our needs satisfactorily until such time as something entirely novel appears, as, for example, an electronic system."

THE EXPANDING FIELD OF APPLICATION FOR STROWGER AUTOMATIC TOLL TICKETING*

By J. E. OSTLINE

SYNOPSIS: *History of automatic toll ticketing developments — essential features — early installations — recent metropolitan applications—system types — facilities and equipment units — system layouts and methods of operation.*

Introductory

WHEN automatic switching is provided in a telephone exchange, the basic advantage obtained is that of enabling telephone subscribers to establish desired station-to-station connections without the assistance of manual operators. The range of these subscriber dialed connections is generally confined, however, to calls within specified limits usually referred to as "local areas". Station-to-station calls to surrounding or nearby points involving "short haul" toll charges are still generally completed by operators via manual switchboards. The basic reason for this method of operation is the necessity of obtaining for each call a "toll ticket" which contains the data required to bill subscribers for short haul toll messages.

Many years have passed since the introduction of subscriber controlled automatic switching for local or free calls, but the provision of manually operated "DSA" (dial service "A") boards for short haul toll or "AB" calls in automatic exchange networks is still the general practice. In addition to these manual switchboard facilities, there have also over the years been developed and placed in service for use in C-A-X (Community Automatic Exchange) networks many so called "dial-back" or "remote control" arrangements which require, in addition to manual switchboards, considerable amounts of special toll and trunk plant equipment to permit establishing short haul toll connections between calling and called automatic stations. All such manual installations and networks require 24-hour staffs of operators and the usual operator accommodations.

The constantly increasing cost of providing these short haul toll services between automatic subscribers in city, county, and C-A-X networks by manual methods has for many years been gradually reducing the net revenue for this type of service to a point where some operating administrations are beginning seriously to consider placing some of these short haul services on a free subscriber dial basis. Other administrations are seeking higher rates. However, on the basis of experience obtained so far, the best solution to this problem appears to be to eliminate manual operation entirely by providing *subscriber dialed* short haul toll service with *automatic toll ticketing equipment.*

Historical

Studies made by the Automatic Electric Laboratories during the years 1921 to 1925 indicated even then that the provision of direct subscriber dialing of short haul toll calls with means for automatically obtaining the basic "ticket data" for billing purposes was both possible and practical. Development of equipment for this purpose was then initiated, and about 1925 this resulted in a circuit and equipment design for automatically ticketing subscriber dialed short haul toll calls (U.S. Patent 1,673,420). While this system provided for subscriber dialing of short haul toll calls with recording of basic call data on a tape recording device, it still lacked several features or facilities considered desirable by many operating administrations. For instance, the registration of the calling station number was not "automatic"; this number had to be dialed by the calling station before the connection could be extended to the called

*Based on an address given before the Erie Section of the American Institute of Electrical Engineers, March 14, 1951.

station. Another feature considered undesirable was the necessity for manually counting and transcribing the marking on the call record tape for each digit of registered call data, before a toll ticket could be prepared for accounting and billing purposes.

In order to add to the ticketing plan as originally developed the various facilities and features which operating administrations considered desirable, the Laboratories continued their work, and by 1937 an automatic ticketing system had been developed which contained the following basic facilities:

(a) Direct subscriber dialing of short haul toll calls.

(b) Automatic identification of calling station number for individual line service.

(c) Automatic computation of cost of call.

(d) Common recording, storing and printing facilities for all ticket data pertaining to subscriber dialed toll calls.

About this time (1937) the Belgian Government Telephone Administration were formulating plans for introducing subscriber toll dialing facilties on a national basis in all future automatic exchange installations. After investigating the various facilities available at that time in the Automatic Electric toll ticketing system, they decided to have it incorporated in a new automatic exchange installation at Mons, Belgium, where it proved entirely satisfactory. A similar automatic toll ticketing installation was placed in service at La Louvière, Belgium, in 1950.

After the completion of the toll ticketing installation at Mons, Laboratory studies were continued to ascertain if the circuits and method of operation used at that exchange would be suitable for large multi-exchange areas in the U.S.A. These studies indicated that the basic arrangement was suitable, but that the automatic station identification would have to be expanded to provide for four-party as well as individual line service. Also, because reduction or elimination of manual labor was one of the basic aims of automatic toll ticketing, it was considered desirable to arrange the exchange equipment in such a manner as to permit the use of automatic accounting equipment in the processing of the message records into final subscriber bills. A system along these lines was developed, and a pilot exchange to test some of the basic facilities of this system was placed in service in 1944 in the Santa Monica, California, exchange of the Associated Telephone Company, Ltd.

The foregoing automatic ticketing arrangement, which is arranged to permit the use of automatic billing facilities when desired, is now referred to as the Strowger Automatic Toll Ticketing (or SATT) system. It is now in operation in four metropolitan area exchanges in the U.S.A. as follows:

Sunland, Calif.
Monrovia, Calif. } Los Angeles Metropolitan Area

Park Ridge, Ill.
Des Plaines, Ill. } Chicago Metropolitan Area

The Commercial Departments of the companies operating these installations are using the automatic billing facility available in all types of the SATT system.

Outline of the SATT System

System Types

To meet various kinds of operating requirements, the SATT system is available in three types, designated as Types A, B, and C.

The Type A system is designed for Director controlled, terminal-per-station (individual and four-party) exchanges in multi-exchange or metropolitan areas. A *detector,* common to each exchange, provides automatic calling station number detection (identification). *Ticketers, tabulators* and *tape perforators* respectively provide storage, tabulation, and recording of call ticket data.

In the Type A system, a calling subscriber, in order to obtain a short haul toll connection, is required only to dial the called station directory number. The Director then automatically routes the call to the terminating exchange, and also, with the aid of the detector, accumulates and transmits to a ticketer the initial data required to produce a call record (ticket) on each completed short haul toll call.

The Type B system is designed for single-exchange or multi-exchange areas of the same kind as indicated for Type A, but with *direct dial control* (non-Director) operation. A detector, common to each exchange, provides automatic calling

station number detection. Ticketers, tabulators and tape perforators respectively provide storage, tabulation, and recording of call ticket data.

In the Type B system, a calling subscriber, in order to obtain a short haul toll connection, must dial a short haul call prefix of two or three digits before dialing a called station directory number. This prefix will extend the call via a ticketer, in which, with the aid of the detector, the initial data required to produce a call record (ticket) is accumulated during the dialing of the called station directory number.

The Type C system is designed for small (less than 1,000 terminals) terminal-per-line or terminal-per-station exchanges and CAX networks. In this system the automatic detector is eliminated. A *verifier,* common to an exchange, is provided to "verify" or check a calling number registration. Ticketers, tabulators and tape perforators provide storage and recording of ticket data.

In the Type C system, a calling subscriber, in order to obtain a short haul toll connection must dial the following items before dialing a called station directory number:

(a) A short haul toll call prefix, of two or three digits.

(b) The directory number of the calling station.

The toll prefix will extend the call via a ticketer. Dialing of a calling station directory number will cause that number to be recorded in the ticketer, and a verifier automatically checks the correctness of the recording. From this point all operations are similar to those encountered in a Type B system.

All three types of systems are similar with respect to the following equipment requirements:

(a) Ticketers are used to store initial call ticket data and to time and record length of conversation on answered calls.

(b) Tabulators and tape perforators are used to record completed calls.

(c) *Dater-Timers* are used to provide timing facilities to the ticketers, and date and clock time to the tabulators for completed calls.

(d) *Station identify (spotter) dials* are required for party line stations in all terminal-per-station exchanges. In Type C terminal-per-line exchanges they may be omitted, but if they are, no verification can be obtained on the station (last) digit of a calling station number.

Principal Facilities

When SATT system operation is provided in an automatic exchange the following facilities are obtained:

(a) Station-to-station connections can be established to stations in short haul toll areas by direct subscriber dialing, and without the aid of operators.

(b) All data required to produce a bill for each completed toll call is automatically accumulated and recorded in a punched tape.

(c) The data provided on the tape can be automatically converted into standard form toll tickets by means of "tape to ticket" printer assemblies available for this purpose. These tickets are then processed for billing in the same manner as manually prepared toll tickets.

(d) Alternatively, the data on the tape can be automatically converted to punched cards by means of "tape to card" punches available for this purpose. These cards in turn are used automatically to produce subscribers' bills and any desired type of commercial records.

(e) Punched call data cards can also be used automatically to produce all types of traffic data pertaining to all phases of short haul toll traffic in a SATT system network.

SATT System Components

Ticketer

A ticketer is composed of relays and rotary switches. Ticketers are associated with outgoing short haul toll trunks or toll trunk selectors. A ticketer is always included in a SATT connection.

The basic function of a ticketer is to store all ticket data pertaining to a toll call (except the date and clock time), to time the call when answer supervision is received, and then to store this conversation time. When the call is completed, the connection is released and the ticketer is automaticaly connected to a tabulator in a common group, into which it then transfers in high speed code all stored data pertaining to the completed

call. At the end of this transfer, the ticketer is available for another call.

If an attempted call does not mature due to "busy", "don't answer" or "abandonment", the ticketer releases instantly when the calling subscriber hangs up, and no tape record is produced. Thus the tape will contain only completed calls, and no time is wasted in scanning non-productive items when the tape is transcribed.

A ticketer may also contain "repeater", "selector control", and "two way" facilities. The inclusion or omission of any or all of these facilities depends on the type of SATT system used and the traffic requirements in each exchange.

Ticket Repeater

A ticket repeater is used in the Type C system for small or remote exchanges when it is desired to concentrate the recording of completed call data at a centrally located exchange.

This unit, in addition to being a normal pulse repeater, also stores and controls the verification of a calling station number.

Tabulator - Perforator - Computer

A tabulator is composed of relays and rotary switches. Tabulators are arranged in small groups common to all ticketers in an exchange via "assigners". Two tape perforators ("ticket" and "record") are permanently associated with each tabulator. The perforators produce the primary record of each completed call in the form of a punched tape which is subsequently used to produce punched cards for automatic billing or printed tickets for manual billing.

When the "cost of call" facility is desired, a computer is included in the tabulator assembly.

A tabulator receives from a ticketer all call (ticket) data pertaining to a completed toll call. It tabulates this data in any desired sequence, computes the cost of the call if a computer is provided, and adds the date and clock time. This data is then transmitted "in reverse" to the perforator tape. Then when the data on the tape is transferred to a ticket printer or a card punch, the tape can be started from the "outside" end, thus avoiding rewinding of the tape.

Both perforators associated with a tabulator receive and record ticket data. In addition to this, in Type A (Director controlled) systems, the record perforator records identity numbers of the basic units involved in each call, i.e., Directors, ticketers, and tabulators. In Type B and C systems identity numbers of the ticketer and tabulator are recorded.

The second or record perforator tape is intended to serve two purposes:

(a) To provide ticket data in duplicate as a safety measure.

(b) To assist maintenance staffs in locating basic unit faults.

Detector

SATT systems Types A and B detect (identify) calling station directory numbers automatically by means of a detector. This is an assembly of apparatus common to an exchange. It is brought into use for about 125 ms. during the dialing of a short haul toll call, during which time it finds and records the calling station directory number.

If a detector fails to find a calling station number before the calling subscriber completes dialing, the connection is automatically extended to an operator who can dispose of the call as desired.

Verifier

The Type C system requires a calling subscriber to dial his own directory number before a short haul toll call can be completed. The correctness of the terminal portion of this dialed calling station number is checked by a verifier unit. This is a relay group common to each exchange. It is brought into use for about 125 ms. during the dialing of a short haul toll call. If no verification is obtained, the call is blocked and the calling subscriber receives a busy or a special tone as may be desired by the operating administration.

Party Line Station Identity Dials

If only individual line SATT service is considered, the automatic detector or the verifier serve to detect or verify a calling station number correctly. But when party line service is provided these equipments cannot detect or verify which station on a party line has initiated the call. Party line station identity service, however, can be provided by the installation of a station identity (spotter) dial at each party line station. This is a standard Automatic Electric dial to which is added

a "spotter" cam and pulse springs. This added facility does not change or in any way interfere with the normal dial function.

The addition of the spotter pulse facility to a standard dial is a factory operation, but spotter cams can be readily changed in the field.

Station identity dials are arranged to cater to four party terminal-per-station service or ten party terminal-per-line service.

Dater-Timer

As the name indicates, this unit provides the date and clock time for each completed call. It also provides the controls which time each conversation. It is common to all ticketers and tabulators in each exchange, and is provided in duplicate.

Clock time is recorded on the "navy" or "twenty-four-hour basis. This unit operates on a four-year cycle and thus provides the extra day for February during leap year without special attention.

Ticket Printers and Tape-to-Card Punches

If toll calls are processed manually for billing, the ticket tape call data is transferred to standard tickets by means of a tape controlled printer. Printers and associated control equipment are placed in the accounting or commercial department of the operating company. Tickets produced can be in standard size and can thus be processed for billing similarly to manually produced tickets. If desired, however, a small size ticket, or a continuous sheet paper record can be provided.

The standard ticket printer provided for printing tickets from tape, prints the ticket data in one continuous row lengthwise. Special printers can be provided, however, which print each item of the ticket crosswise, but being of a more complicated design these printers are costlier than a standard type.

If complete automatic billing is desired, the ticket tape call data is transferred to punched cards via a tape-to-card punch. After punched cards are obtained, bills and record ledgers are produced automatically by the card processing equipment.

Ticket printers or tape-to-card punches are completely independent of telephone exchange switching equipment and hence may be located anywhere, generally in the commercial or accounting department of the operating company. Furthermore, since the same tapes are used in either device, an operating company may start SATT operation with tickets on a manual basis and change to punched card operation at any time by the provision of punched card equipment.

Punched card operated equipment including the tape-to-card punch can be obtained from firms manufacturing this equipment.

SATT System Layout and Operation

Block diagrams of the three basic SATT systems are shown in Figures 1, 2, and 3. The layout of these diagrams is such that it is apparent at a glance which equipment is common to all three and what equipment is omitted as we go from the larger to the smaller systems.

As has been indicated previously, the Type A SATT system shown in Figure 1 is intended for use in Director controlled networks. Such an area would have a universal numbering scheme. To make a short haul toll call a subscriber simply dials the directory number of a called station. No special toll codes are required, and so far as the user is concerned the call is dialed exactly like a local call. The operating and economic aspects of the Type A system have been discussed in detail by Mr. J. T. Naylor in an article entitled "Application of Strowger Automatic Toll Ticketing and Punch Card Toll Accounting in Metropolitan Telephone Networks".[1] The operation of the Director was described by the author in an A.I.E.E. paper entitled "The Universal Director in Strowger Automatic Telephone Systems".[2]

As indicated previously, the Type B SATT system is intended for non-Director areas of any size. The block diagram of this system (Figure 2) shows that the essential difference between Types A and B is that in Type B the Director with its translator are omitted, and the detector is connected directly to ticketers.

In Type B operation, a ticketer is reached by dialing the first digit of a special two digit toll code, which in the diagram is "90". The second digit is used to establish certain conditions in the ticketer. The remaining digits to be dialed depend upon the

1. The Automatic Electric Technical Journal, February, 1950.
2. Trans. A.I.E.E., Vol. 60, P. 1080-87, 1950.

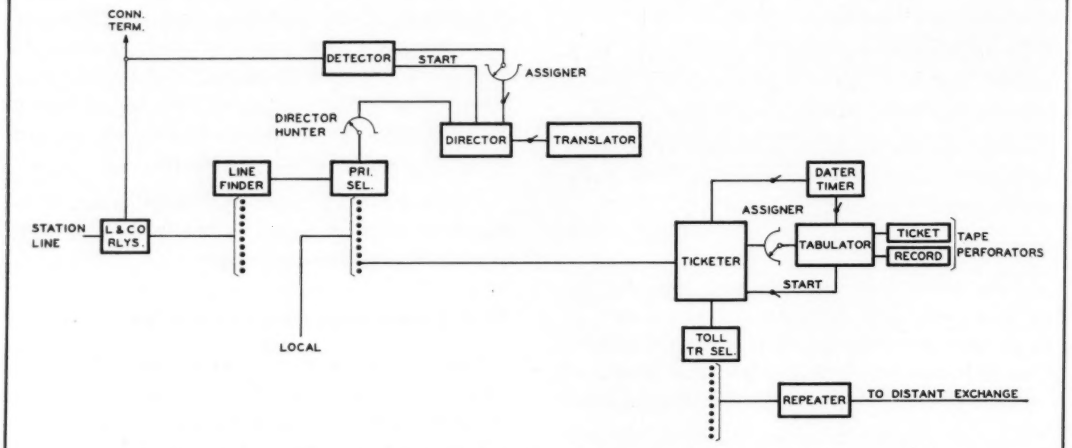


Figure 1. Block diagram of Type A SATT System (for use in Director-controlled networks).

numbering and trunking layout of the system and are not altered in any particular by the addition of SATT operation. If the system has universal numbering it is considerably simpler from a user's standpoint since all he needs to do is to dial the toll code and then the directory number of the wanted telephone, and the complete number to be dialed to reach a given station will always be the same regardless of the point of origin. However, if universal numbering is not in use, then special directory instructions must be provided to show how to reach subscribers in any of the several exchanges in a network. In general, under such conditions, the number dialed (after the toll code) will consist of one digit to reach the trunk level representing the called exchange, plus tandem switching digits, if any, plus the terminal directory number of the called station.

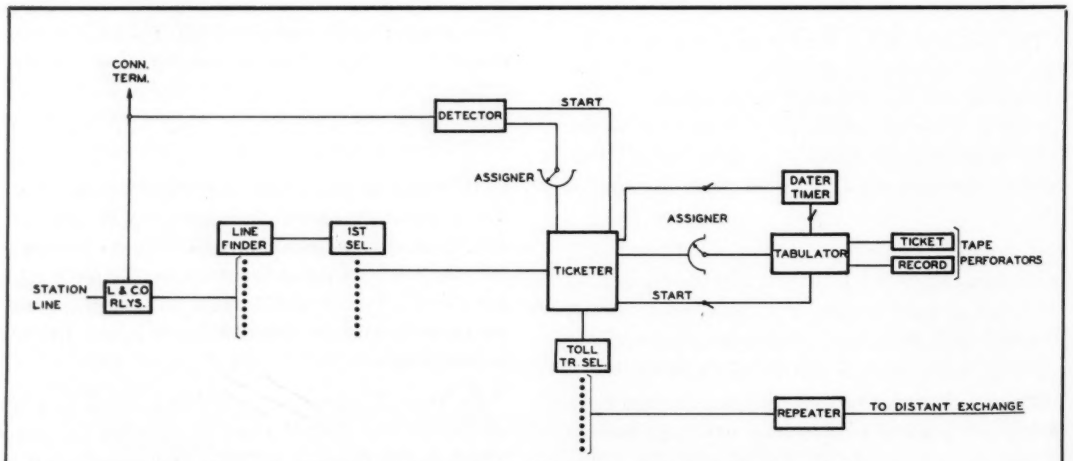


Figure 2. Block diagram of Type B SATT System (for non-Director areas).

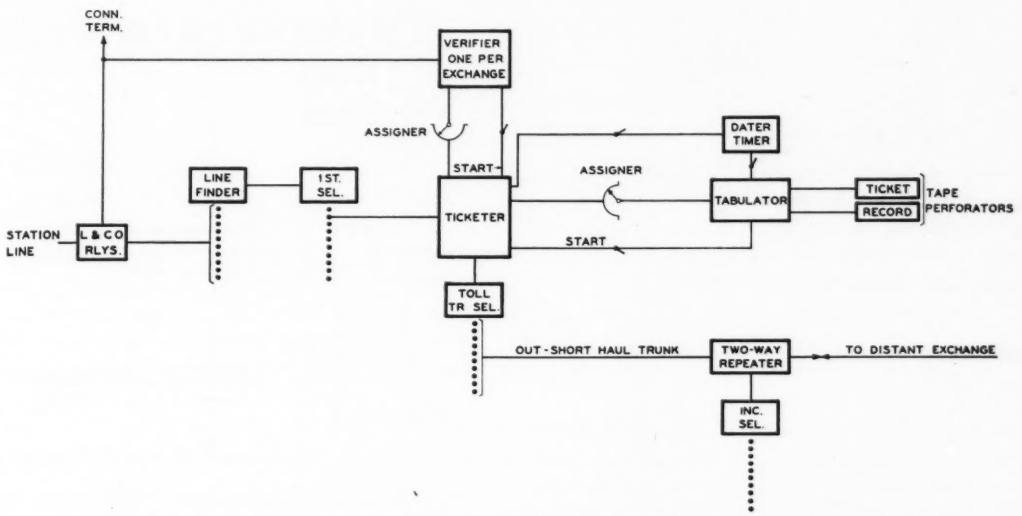


Figure 3. Block diagram of Type C SATT System (requiring dialing of calling station number).

In the Type B system (as also in the Type A) the detector, ticketers, etc. will all be located in the same exchange building as the local switching equipment. The tape processing equipment will ordinarily be located in the commercial department of the operating company. Where several exchanges are operated by one company, all the tape data can be processed at a common point.

The Type C SATT system, as will be seen from Figure 3, is greatly simplified. The automatic detector is omitted and in place of it we have a verifier. The remaining units of equipment are the same in name and function but not necessarily the same in physical arrangement and circuit details.

The layout of Figure 3 is typical for a small exchange requiring selectors. However, the system is very flexible and many variations are possible. Figure 4 shows one such variation. In this case, town *X* has a very small switchboard that does not use selectors, and it therefore becomes more economical to place all of the SATT equipment except the verifier in town *W*, which can be considered the center of a small network. In operation, the subscriber in town *X* first dials a two-digit toll code. The first digit seizes a toll repeater and trunk to *W* and the second digit of the code, which is "O", conditions the repeater to accept the toll call. The number of the calling station is then dialed, and this is recorded in both the ticket repeater in *X* and the ticketer in *W*. The ticket repeater in *X* seizes the verifier which checks the number recorded. If verification indicates "correct", the call continues without interruption. If verification indicates "not correct", the connection is blocked at the ticket repeater and busy tone returned to the subscriber.

On a call verified as correct, the calling and the called station number are recorded in the ticketer in *W* at the same time the connection is being set up. Upon the release of a completed call, the ticket data is transferred to a tabulator and subsequently punched in a tape. The ticket repeater at *X*, in addition to its usual repeater function, is provided with storage equipment for a calling station number. The ticketer in *W*, in addition to usual ticketer functions, also contains "repeater" and "both way" facilities.

The layout shown in Figure 4 is particularly appropriate when *W* is the center of a network surrounded by several small exchanges similar to *X*.

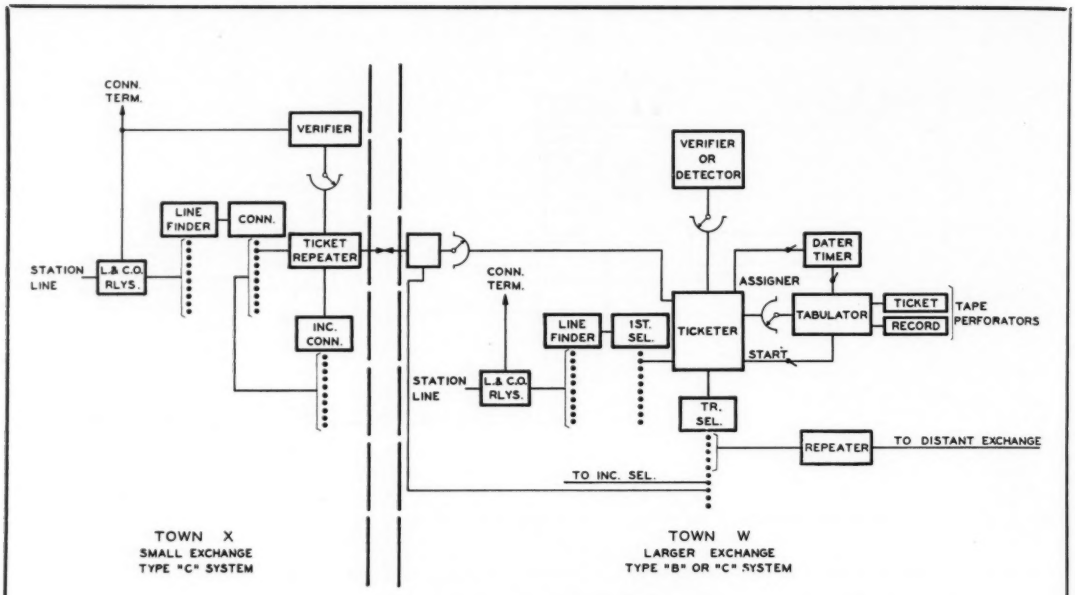


Figure 4. Block diagram of Type C SATT System, with SATT equipment in central exchange of a network.

A ticketer would, of course, be individual to each of the various toll trunks in *W*, but tabulators and associated equipment are common to all calls originating in *W*, as well as in *X* and other similar exchanges. There is also an operational advantage in having the tape records made in a central location, since it eliminates the necessity of someone having to make a special trip to each small exchange to collect it.

Conclusion

The operating experience now being obtained with the SATT system in this country and abroad indicates that it economically and efficiently provides the following advantages:

(a) Eliminates manual toll boards and all other special plant, equipment and building space required to provide manual short haul toll service.

(b) The foregoing also eliminates manual operators and manual equipment maintenance staffs.

(c) Direct subscriber dialing provides a fast, convenient and uniform service.

(d) Toll trunk efficiency is increased due to instaneous release at the end of each conversation.

(e) Mechanical timing under control of the calling party insures accurate and full circuit time revenue.

(f) Mechanical accounting and billing can be used whenever desired. The SATT system is arranged to operate with all standard types of punched card accounting systems.

(g) No special maintenance staffs are required because all basic SATT units are built up from standard Strowger apparatus and components. Tape perforators and tape transcribing equipment are standard items similar to those used in present day telegraph service. Maintenance methods and parts for these units are therefore standard items.

TOLL ANSWERING DELAYS AND THEIR MEASUREMENT

By IMRE MOLNAR

SYNOPSIS: *Types of toll answering delays — standards of service — observable delay components — measurement of toll delays — the Delay Register: its construction and application.*

IN any telephone system in which at one stage or another the aid of an operator is required to complete a connection, the grade of service given can be judged in two ways: by the number of wrong connections; or by the amount of delay before service is given. The latter measure is the one customarily employed, particularly in toll operation, where the number of wrong connections is negligible.

Types of Toll Answering Delays

In local manual work the only delay which can be attributed to the operational features of the telephone system is the length of time the calling subscriber is required to wait before the operator answers. In toll operation, however, delays may occur at various stages of the connecting process (see Figure 1). The various conditions under which delays are encountered are given hereunder:

(a) The subscriber, having secured the CLR trunk circuit, must wait until the operator answers. This delay, although averaging only two or three seconds, is the central figure for determining the grade of service.

(b) The operator, in answering, obtains the particulars on the desired call and the calling party. This is an unavoidable delay, which may be reduced by training the operators or educating the public, but is in no way affected by the techniques of the telephone system or adequacy of the operating force.

(c) When the operator is ready to proceed she attempts to reach the toll line group. Here a circuit may be available or all of them may be busy, including alternate routes if such exist. If all circuits are busy she may make another attempt a minute or so later, holding the calling subscriber on the line and attending to some other business in the meantime. If she is again unsuccessful, or if she knows beforehand that congestion will prevail, she informs the calling subscriber that he will be recalled in due course, and requests him to disconnect. The ticket is now passed to a delay operator who takes over from that point. This condition is the most serious cause for delay and is entirely dependent upon the size of toll circuit groups and the amount of traffic they are expected to carry. It is, therefore, a problem of toll circuit engineering, and no changes in the switching equipment or in the operating efficiency within the toll office will affect this delay to any appreciable degree. This problem, however, is a very important one, since the overall quality of service is profoundly affected if too few circuits are available.

(d) The destination of the call may be a terminal point to which a direct circuit is available, or the call may have to be switched through one or more immediate points. Furthermore, the connection may either be established by the intervention of an inward operator or by intertoll dialing. If the call is switched through intermediate points, the delays inherent in through switching are cumulative and correspond to the delays previously described. If the call is answered by an inward operator there is a delay similar to that defined under (a), although it is of lesser magnitude, since every effort is made to keep such delays short in order not to tie up valuable toll circuits and the distant CLR operator unnecessarily.

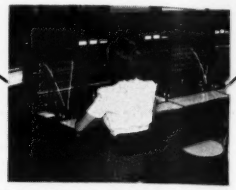
(e) The time required for the connection to be extended to the called subscriber at the terminating point will mostly depend on the technique of local operation there, and nothing in the toll system would have any bearing on it.

CALLING SUBSCRIBER: After the subscriber dials the long-distance code, delay occurs when he waits for the CLR operator to answer. The length of this delay depends upon the technique of the telephone company and the adequacy of its operating force.

CLR OPERATOR: After the CLR operator answers, delay occurs when the operator obtains particulars from the calling subscriber.

Further delay occurs when the CLR operator attempts to reach the toll line group. If all direct routes are busy, the operator may select an alternate route, if such exists.

Delay will also occur when the CLR operator waits for the inward operator to answer at the intermediate or terminating point.



INTERMEDIATE POINT: If an alte nate route is selected, the inward an through operator at the intermedia point will forward the call to th terminating exchange.

Figure 1. Sources of delay in a long distance call.

(f) After the called subscriber's terminal has been reached the connection may be satisfactorily established, in which case the delay has terminated; or the conversation may not take place for any one of several reasons such as: no answer, line busy, desired party on a person-to-person call not available, etc. In most such cases the ticket will be passed to the delay operator at the originating point and the calling subscriber informed that he will be recalled in due course. Such delays may be very substantial, but they are entirely beyond the control of the telephone company. This fact is generally understood by the telephone users, so that such delays are not charged against the quality of the telephone service; on the contrary, the efforts of the telephone company to establish connections under these conditions are appreciated as a contribution to service quality.

Among the delays described above, the one assuming the greatest importance in an appraisal of the quality of service given by the toll office operating force and equipment is that given under (a)—the time taken by the operator to answer after the calling subscriber has secured a CLR trunk circuit.

Standards of Toll Service

According to the present standards an excellent grade of service is given if 95% of the CLR calls and 97% to 98% of the inward calls are answered within ten seconds. The ten-second objective for 95% of the calls was established originally for local manual operation, where a subscriber may reasonably expect prompt attention on local calls of which he makes perhaps a dozen each day. After the operator has answered it takes only about ten seconds to complete the connection locally and only a little longer if other offices are involved.

With toll traffic, the situation is quite different. The originating toll traffic averages about 0.1 calls per subscriber per day, the calls going usually to communities at a considerable distance. The subscriber understands that to set up such a call is a more complex operation than for an ordinary local connection; instead of the ten seconds required to complete the average local connection he will have to wait an average of over two minutes after the operator answers before he can begin the conversation with the called party, and if the call cannot be promptly completed, he will have to wait until he is recalled at some later time. Under these circumstances the question may be raised whether the subscriber really expects the operator to answer in an average of two seconds (which conforms to the 95% objective specified in the foregoing), if he has to wait another two minutes before his call can be completed. If 95% of the calls are answered within ten seconds it means that not even once in six months, on the average, will the subscriber be delayed for more than ten seconds by the operator.

TERMINATING OPERATOR: The inward operator at the terminating point will take the call from the CLR operator.

Delays occurring at both the intermediate and terminating points will be similar to the delays encountered when the call was handled by the CLR operator, but will generally be shorter.

LOCAL MANUAL BOARD: In automatic offices, a toll call will be terminated in an automatic switch train. If the terminating exchange is manual, the inward operator will extend the call through the local manual board. Brief delays, similar to "inward-operator" delays, will occur here.

CALLED STATION: After the called subscriber's terminal has been reached, the delay will be ended unless the line is busy, the called party does not answer, the call is answered but the desired party on a person-to-person call is not available, etc.

The 95% level, however, may be justified from several other aspects. First, while it is convenient to operate with average figures for computations, averages cannot be indiscriminately applied in engineering, and in no case should they be applied to matters which may concern public relations. There is no such thing as an average telephone user. While there are many subscribers who seldom or never make long distance calls, there are, on the other hand, many others who consistently make several such calls every day. The first type of subscriber may be perfectly satisfied if the average delay in answering his calls were several times the two-second average indicated above, heavy toll users and particular PBX operators would feel considerably inconvenienced by an average delay of, say, ten seconds or more.

Second, it is easy to show, both by theory and by actual observation, that regardless of what objective is set (in this case a delay of ten seconds or less for 95% of the calls) some of the calls will still be delayed several times as long; in fact, theoretically even infinite delays are possible. For instance, actual service observations indicate that where 95% of the calls are answered within ten seconds, delays up to 30 seconds are still experienced. Delays of such length, even if they happen but rarely, are particularly annoying to heavy toll users and PBX operators, and the rate at which such subscribers abandon their calls under these conditions is appreciable.

Third, the adjustment of the operating force and the computation of equipment quantities are based on a limited number of traffic observations, and can be considered adequate only so long as conditions remain as anticipated. If, however, an unusual demand for toll calls develops suddenly, the delays, unless they are normally short, would virtually choke the traffic.

From the above it appears that it is a reasonable objective to provide enough operators and equipment so that 95% of the calls will have a delay of not over ten seconds. From a practical point of view it would seem to be more convenient to specify the average delay of all calls instead, since such an average is easier to measure and compute, is independent of any particular sequence in which calls are answered, and characterizes the quality of service with a single figure. Nevertheless the average delay is not a suitable quantity to express the grade of service in manual operation. It is another case where use of the "average"—often a very useful tool in engineering—may tend to camouflage the actual conditions. For example, a large proportion of calls will be answered with virtually no delay at all, another fairly large proportion with very little delay, and so on, with the proportion of calls progressively reduced as the delays get longer. There will nevertheless be some calls which are

delayed for what might be considered an excessive length of time. While the average of all these delays will be small (in the order of two or three seconds), this will be little comfort to those who have to wait 30 seconds or longer. Therefore a better way to express the grade of service is to state the percentage of calls which exceed a given length of delay.

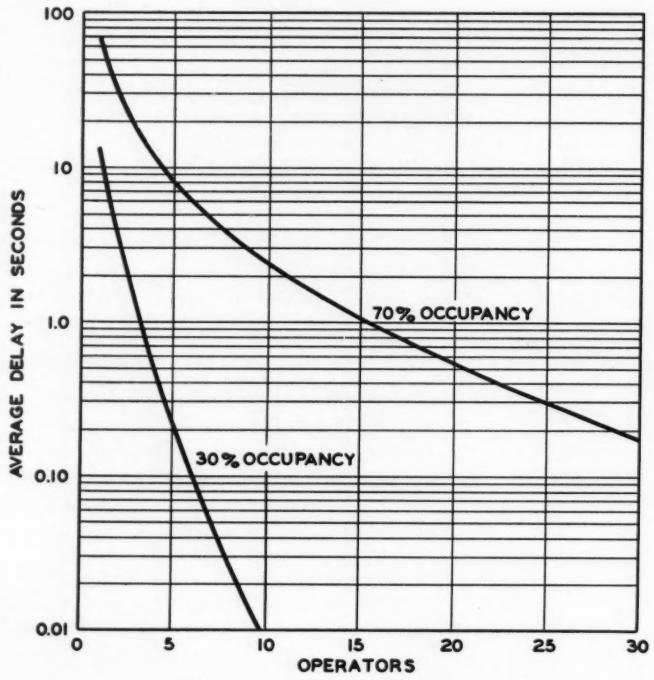


Figure 2. Average delay for service, given the percent occupancy and number of operators. (One minute work time per call was assumed.)

Theoretical vs. Observable Delays

To illustrate the conditions defined in the foregoing, Figures 2 and 3 were prepared from certain equations derived from probability theories based on constant holding times (not the total holding time, but only the time the operator is engaged with the call), which is sufficiently correct for the work time of operators. Actual observations indicate that these theoretical results are in close agreement with the actual delays, if certain small and predictable corrections are applied. In Figure 2 the average delay per call is shown for different-sized teams of operators. Besides the number of operators in the team, the average delay will depend on two factors: the proportion of time, on the average, during which each operator is effectively occupied with furthering the progress of a call, and the length of work time required for each call which, as mentioned before, can be assumed in this case to be the same for all calls. Of course, the larger the proportion of time each operator is occupied the longer will be the delay, and, likewise, the longer the work time per call the longer, on the average, must a call wait before an operator becomes available.

In Figures 2 and 3, it is assumed that the work time per call is one minute; and the average delays in Figure 2 are given in seconds for 30% and 70% occupancy. In Figure 3, the maximum permissible percent occupancy for various-sized teams of operators is given, if not less than 95% of the calls are to be answered within ten seconds. For instance, from Figure 3 it can be seen that 13 operators could be occupied 70% of the time at the specified grade of service, while according to Figure 2 the average delay per call for that number of operators would be about 1.5 seconds.

Delays of such magnitude are seemingly unimportant, but if the matter were further pursued it would be shown that three calls out of each 1000 would be delayed over 30 seconds. A toll board of such size would handle several hundred calls during the busy hour. Therefore it could be expected that during the busy hour each day, and to a lesser degree during a few hours outside of the busy hour, one or two calls would have to wait more than 30 seconds for service. The reason why one would not suspect this situation to exist from the magnitude of the average delay (1.5 seconds) is

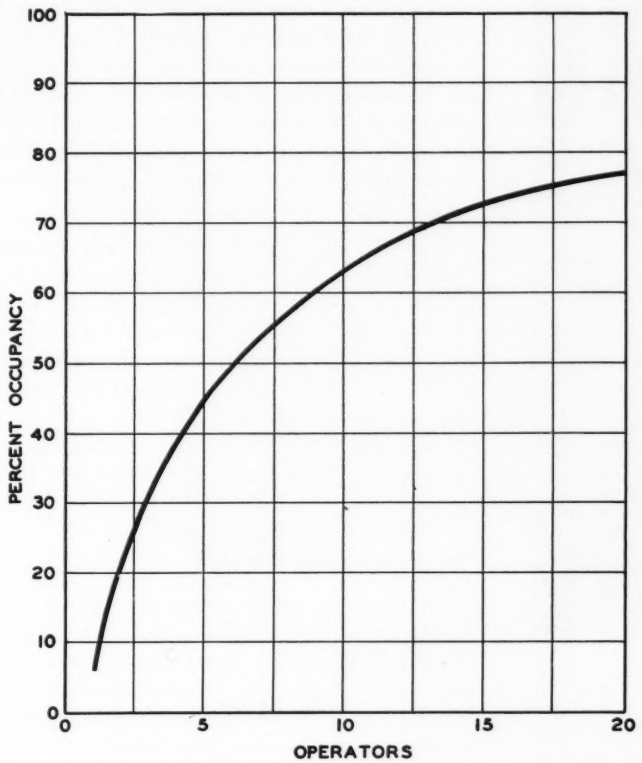


Figure 3. Percent occupancy, given the number of operators, providing 95% of the calls are to be answered within ten seconds. (One minute work time per call was assumed.)

that, with the given number of operators and percent occupancy, about 90% of the calls should theoretically be answered with no delay at all.

By the statement in the last sentence it is implied that there will be some discrepancy between the theoretical and the observable delays; and this is another reason why the average delay is not a suitable measure for the grade of service. Delays which are computed from the theory are always created during the periods when there are more calls made than there are operators momentarily available, so that some of the calls have to wait until others are processed. Even during the busy hour, if the correct number of operators are on duty, it will often happen that when a new call comes in there will be one or more operators idle, and such calls, of course, would not have to wait at all. This, however, tacitly assumes that the mechanical process of answering is instantaneous and does not require any time. Actually, in cord type operation for instance, it takes a certain minimum length of time for the operator to notice the signal, pick up a cord, plug into the answer jack, and operate the talk key; or, in the case of an automatic toll board, for the mechanical switching equipment to select the calling trunk and connect it to an idle operator. This basic delay varies somewhat; the variation will be slightly greater in cord type operation, and more uniform with automatic operation, but in any case it wil fluctuate within a fairly narrow range. Averaged over a large number of calls there will be a basic delay value which cannot be eliminated, and to which every call is subjected even should every operator be idle and ready to answer immediately. The magnitude of this basic delay is not great; it can be both computed and observed, and is between one and two seconds, dependent on various factors. However, as can be seen from Figure 2, this is of the same order of magnitude as the average delay due to congestion; as a matter of fact, for large team sizes the average "congestion" delay is considerably below this minimum basic delay.

Now the average delay actually observed is the sum of the basic delay and the average delay due to congestion. Since the first part may be as great or greater than the latter, a relatively small change in the observed delay could be caused by an unproportionately large change in the average delay due to congestion, and this again may mean a very radical change in the grade of service. Therefore, the observable average delay is unsuitable to express the true quality of service.

In using graphs similar to Figure 3, or specify-

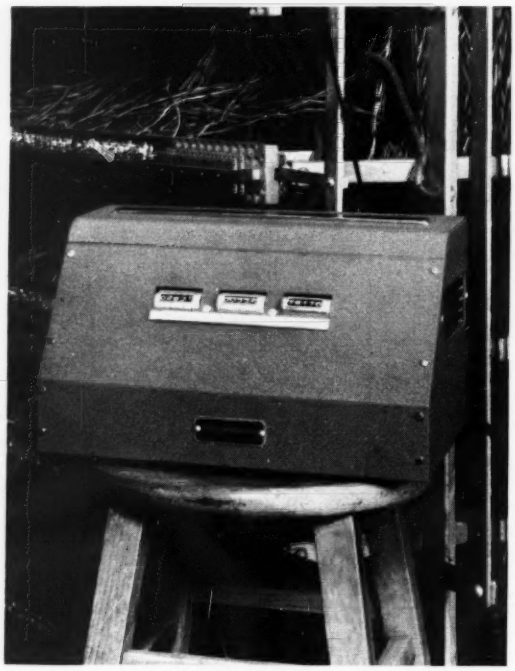


Figure 4. Traffic Delay Register.

ing delay objectives such as the "95% within ten seconds", one must keep in mind that the delays distribute themselves around the average, depending upon the sequence in which the calls are answered. For instance, Figure 3 is based on the assumption that the calls are answered in the same sequence as they were originated. On the other hand, it is known that if calls are answered entirely at random, that is, without any regard to the sequence in which they were originated, a larger proportion of calls will have long delays than if they are answered in strict sequence. To compensate for this a large proportion of calls will have extremely short delays, so that the average is the same in both cases. With sequence answering, however, the delays are clustered a little closer to their average.

Measurement of Toll Delays

For every amount of work load the proper number of operators can be specified from tables, which are based on the probability that a given delay will not be exceeded for a given proportion of calls. Observations confirm the validity of the theoretical prediction, if the basic delay and the true effective occupied time of the operator are included in the computations. With the size of the operating force and the amount of equipment so determined, it remains to keep a regular check on the performance of the toll office to see if the specified quality of service is actually maintained. For this purpose either the average delay or the percentage of calls delayed above a certain length of time, say ten seconds, can be observed.

From what has already been said, the latter count is the more important one and should be used wherever feasible. The practice has been to employ stop-watch observations of the length of delay, or to use a pen recorder which produces a chart from which the individual delays are subsequently measured. Both of these methods are rather tedious and neither one is sufficiently accurate, unless the number of calls observed is very large.

The Traffic Delay Register

To avoid the shortcomings just described the Traffic Delay Register, shown in Figures 4 and 5, was developed, which automatically performs the necessary analysis needed to determine the grade of service, and in addition is versatile enough to be of use in many other applications.

The Traffic Delay Register is a compact portable unit which can be connected to practically any circuit for which the delay is to be analyzed. Essentially, it consists of two counter circuits and a delay accumulator. There are two input points to the Register: at one of the points ground is applied from the circuit under observation as long as the latter is seized but service is not given, and the other input is grounded once each time the circuit is used.

Figure 6 shows schematically how the register can be connected to a CLR circuit of an automatic toll board. The *CW* terminal is grounded from the moment the CLR trunk circuit is seized until the call is answered by an operator, while the *PC* terminal is momentarily grounded each time the CLR trunk is used. If, instead of an automatic toll board, the CLR trunk circuit of a cord type board is to be observed the *CW* terminal may be connected in parallel with the answer lamp of the trunk circuit; thus the terminal will be grounded as long as the answer lamp is operating.

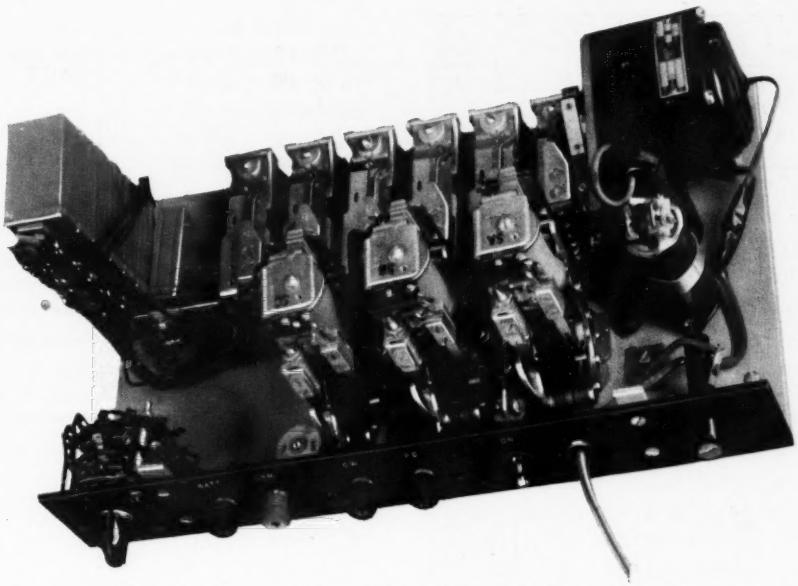


Figure 5. Uncovered view of delay register, showing rear panel.

Inside the Delay Register, the accumulator is driven by a very accurate ten-pulse-per-second source as long as the *CW* terminal is energized; therefore the total amount of delay occurring on the circuit under test is accumulated in units of one-tenth of a second. The accumulator works in a start-stop fashion: as soon as the external circuit is seized and the *CW* terminal is energized, it immediately begins to add to the previously accumulated delay, and stops as soon as the circuit is answered and the potential removed from the *CW* terminal.

Together and in synchronism with the delay accumulator the first of the counters is activated whenever a potential is applied to the *CW* terminal. This counter also accumulates the delay, but it resets itself after every call, so that it begins each time with a zero delay. After a ten second delay is accumulated, the counter takes one count and stops, regardless of how long the call is delayed beyond ten seconds. On the other hand, if the call is answered within ten seconds it resets itself without taking a count. Thus the total number recorded by this counter equals the total number of calls delayed over ten seconds. (However, by a tap switch incorporated into the circuit, it is possible instead to count the number of calls delayed beyond 1, 2, 3, 4, 6, 12, 20, 30, or 60 seconds.)

The second counter simply registers the number of calls passing through the circuit under observation. There are three electro-mechanical counters on the front panel of the Delay Register. The "total" counter indicates the accumulated delay in seconds, as recorded by the delay accumulator. The "delay" counter shows the number of calls delayed over ten seconds. The "PC" (peg count) counter shows the total number of calls passing through the circuit.

The three counters should be read at regular intervals, such as at the beginning of each hour, or at the beginning of the busy hour only, or once a day, depending on the period in which the grade of service is of interest. The differences between successive readings furnish the required data for the period under observation. Dividing the reading of the "delay" counter by the reading of the "PC" counter gives the proportion of calls delayed over ten seconds, thus expressing the quality of

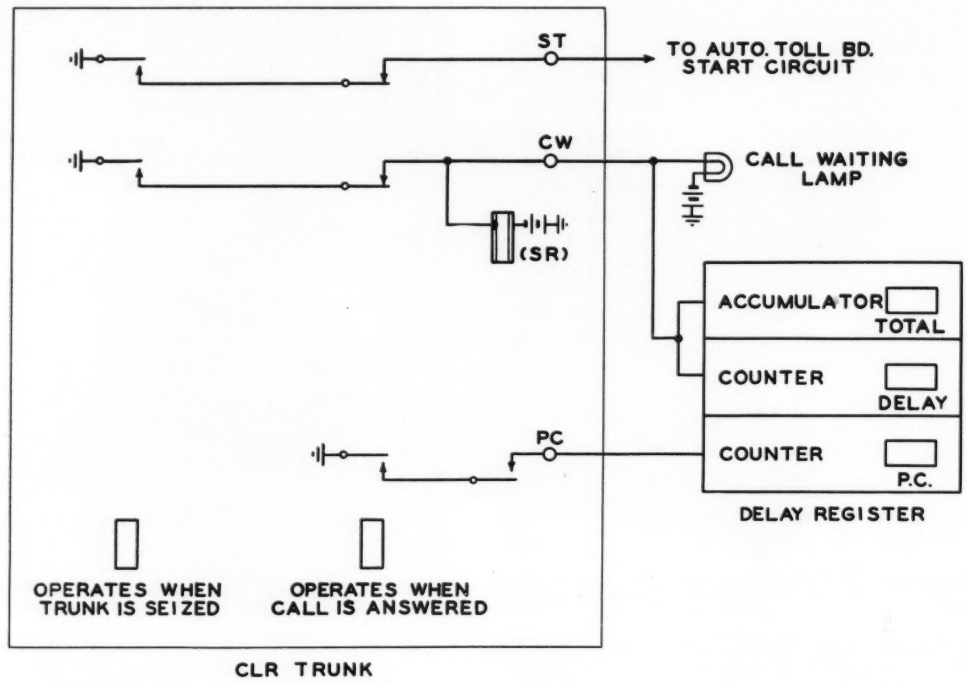


Figure 6. Diagram of the Traffic Delay Register connected to a CLR circuit of an automatic toll board.

service given by the board. Dividing the reading of the "total" counter by that of the "PC" counter gives the average waiting time in seconds. Thus, with the Traffic Delay Register it is possible to obtain the grade of service by two counter readings —one at the beginning and one at the end of the observation period—plus one slide rule operation. The accuracy of the procedure is very high: the actual delay lengths are measured to the nearest one-tenth of a second, the registrations of the two counter circuits are exact. Outside of the possible one-tenth of a second margin it is in no way affected by the observation procedure.

Since service observations rarely, if ever, include 100% of the traffic, but are restricted by practical considerations to a representative proportion, it is extremely important to schedule the sampling procedure so that it will be quantitatively representative. One item to be considered is the size of the sample; that is, the number of calls to be observed in each hour, as well as the number of hours to be observed, so that the end result will be typical of the overall traffic. The correct number of observed calls can be determined by the usual methods of statistical sampling.

For instance, in a study to determine the grade of service provided in inward toll operation, it was found that ten days observation, sampling somewhat over 500 calls per day sufficed to give usable results. (It was also shown that the same results could have been reasonably well predicted by applying the probability theory.) In general, this sample size represents about the lower limit of an observation program, and a sample about twice its magnitude would be preferable. However, as the sample size is increased, one soon reaches the region of diminishing returns, and to extend the program beyond this would be useless, unless a continuous check on the service of the toll office is desired. If such a check is desired, it can be ob-

tained with little expense or effort, due to the extremely simple procedure of the Delay Register.

Even more important than the size of the samples is their selection, that is, the selection of circuits to be connected to the Delay Register. If the observation is to be made on a group of circuits each carrying approximately the same proportion of the traffic, any one of these would be suitable for observation and the measure of the grade of service obtained will be the same as that of the complete group. For instance, some automatic toll boards are equipped with a sequence answering circuit through which every call must pass before being allotted to a position, so that the calls are answered in the sequence in which they were originated. Such a sequence answering circuit consists of a number of call storage units, each one of these being used in rotation; therefore, if the Delay Register is connected to any one of these units, the result after a prolonged period of observation will provide a measure of the grade of service for the entire office.

In other instances the traffic is not inherently equally distributed among several components, but is distributed entirely at random, so that any individual trunk may show a considerable fluctuation within a limited period. However, if the traffic is truly distributed at random, these fluctuations will smooth out over prolonged observation so that the observation of any one of the trunks, if carried out long enough, will be representative of the overall grade of service.

Where the distribution is neither inherently equal, nor entirely at random, but according to some pattern, one must proceed very cautiously in choosing samples in order to avoid obtaining misleading results. A typical example of this problem is a group of CLR trunks which are reached from graded selector outlets. If the delay in answering CLR calls is to be determined, no single trunk circuit will be representative of the grade of service for the complete group. If the trunk circuit is connected to an early choice on the selector level, it will not only carry a larger proportion of traffic than others, but also be used all the time, all through the day and night. Therefore, from the total number of calls observed through that trunk circuit the proportion occurring during the light traffic hours will be larger than the corresponding proportion from the total daily calls.

On the other hand, if the trunk circuit is the last choice of a selector outlet, it will only be used during the busy hour and even then only a fraction of the time. Therefore the number of calls passing through it will be those made during a peak traffic period, when presumably the delays are the longest. Thus the grade of service computed from that trunk would be much worse than actually experienced. In order to observe the quality of service on such graded trunk groups it will be necessary to observe the delays on each trunk for a certain length of time over as many different choice trunks as necessary to arrive at the correct cross section of the traffic for the complete group.

Although the Delay Register was specifically designed for the one purpose of measuring toll call delays, it turned out to be a very versatile and useful device. For instance, the problem came up to determine the time required for a call to go through a certain functional chain of circuits. The Delay Register input was connected to a certain point of the chain which was grounded at the moment of seizure of the chain and ground removed immediately after the call cleared through. Two sets of approximately 100 calls each were sent through the chain in rapid succession, and the average length of time required for each call determined by dividing the reading of the "total" counter by the reading of the "PC" counter. Use of the Delay Register to solve this problem proved justified as the average times obtained for the two sets of calls differed by less than 1%.

Conclusion

It will be apparent from the above description of the Traffic Delay Register that this device is extremely simple to connect for recording data relating to delays in the handling of traffic. However, the interpretation of such data and the drawing of conclusions as to what corrective measures, if any, need to be applied is not a matter to be undertaken lightly, but requires a thorough understanding of traffic and operating principles and how they relate to particular types of equipment. Telephone operating personnel and others who have occasion to use the Traffic Delay Register are invited to consult with Automatic Electric engineers with the view of insuring that the information developed from use of this device will be soundly applied.

POWER EQUIPMENT IN STROWGER AUTOMATIC TELEPHONE EXCHANGES

By N. SALVESEN

SYNOPSIS: *Storage batteries for telephone exchanges — charging equipment—rectifiers and motor generators—ringing and tone equipment—power shelves and power boards—emergency power supply—stationary and portable units.*

FIGURATIVELY speaking it may be said that the heart of an automatic telephone exchange is its power plant. Certainly the efficient operation of the automatic switching equipment depends largely upon the proper functioning of the power equipment. This equipment must be designed to insure ample power availability and to maintain that power within the voltage limits required for dependable switch operation.

Furthermore, it is of the utmost importance that ample provisions be made not only for the initial requirements, but also to permit future expansion of the exchange with minimum changes in the power equipment.

The power facilities required in an automatic telephone exchange generally consist of the following major items:

(a) A storage battery for supplying direct current for operating the switching equipment, and for supplying transmission current to the telephone instruments.

(b) Charging equipment for maintaining the storage battery in a fully charged condition.

(c) Ringing equipment for generating the required alternating ringing current, and apparatus for producing the various tones and impulses necessary for the proper functioning of the exchange.

(d) A power board for controlling the power to equipment, for distributing the power to the various equipment groups, and for providing necessary exchange supervisory signals.

(e) An emergency generator set to supply alternating current in case of failure of the commercial power supply. Generally this is provided only for medium size and larger exchanges.

The items listed above will be more fully described in subsequent paragraphs.

The Storage Battery

The function of the storage battery in an automatic telephone exchange is twofold: first, it acts as a filter between the charging equipment and the automatic switching equipment in order to eliminate hums and other noises which might interfere with voice transmission; second, it provides a reserve source of power for use if the charging equipment should fail, or if the commercial current supply for any reason should be cut off.

Power plants for automatic telephone systems supplied by Automatic Electric Company are designed to operate on the "full float" principle. Under this method of operation the charging equipment is normally "floated" across the terminals of the battery, thus maintaining the battery at the required voltage and in a fully charged condition. The exchange load will, therefore, under normal conditions, be carried directly by the charging equipment at a uniform potential sufficiently above that of the storage battery to replace any battery losses which might occur. When for any reason, the charging equipment is not operating, the exchange load will be carried by the battery.

The number of cells comprising a storage battery in a 48-volt automatic telephone system varies somewhat, depending upon the type and size of the system. In private automatic systems operating on 48 volts, such as Type 25 and Type 50 P-A-B-X's, the battery generally consists of 23 cells. When the battery is operated in conjunction with a constant voltage rectifier, such as the Convotrol, this arrangement represents just about the simplest power plant available, and is quite satisfactory for private branch exchange operation.

Figure 1. Typical arrangement for a 26-cell telephone storage battery.

In unattended automatic telephone exchanges, such as those using Automatic Electric Company's Types 10 and 11 M-A-X equipment, it is generally desirable to provide a greater power reserve than economically can be obtained by the use of a 23-cell battery. For such exchanges the practice is to provide a battery consisting of 24 regular cells and one counter-electromotive force cell, usually referred to as a counter cell. The purpose of the counter cell is to oppose the voltage of the 24-cell battery with a voltage approximately equal to that of one regular cell, in order to reduce the bus-bar voltage of the 24-cell battery to the normal exchange operating voltage. Under normal operating conditions the counter cell is connected in the discharge circuit. If, however, due to an excessive load, or due to failure of the commercial current, the voltage at the equipment falls to the low voltage operating limit, the counter cell will automatically be shorted out of the discharge circuit, and the full voltage of the 24-cell battery will be connected to the bus-bars. The exchange will then be able to utilize the maximum battery capacity before the voltage falls below the operating limit of the switching equipment.

The additional power reserve obtained by the use of 24 regular cells and one counter cell may be illustrated by the following example:

With a busy hour load of 20 amperes, a 23-cell, 200-ampere-hour battery would provide 5 busy hours reserve. Under the same conditions, a battery consisting of 24 regular cells and one counter cell would provide 9 busy hours reserve. Or, if 5 busy hours reserve is wanted with either battery, the capacity of the battery having 24 regular cells and one counter cell need only be 130 ampere-hours, instead of 200 ampere-hours. From the foregoing it is evident that the arrangement consisting of 24 regular cells and one counter cell provides greater utilization of battery power than can be obtained with a corresponding 23-cell battery. The counter cell control equipment is simple and reliable, and is especially suited for use in unattended exchanges.

In medium sized and larger automatic telephone exchanges it is the general practice to provide batteries consisting of 23 regular cells and 3 end cells. The cell arrangement of a 26-cell battery is such that the 23 cells are normally connected in the discharge circuit while the 3 end cells are held in reserve for emergency purposes, or for use when the charging equipment is shut down at night or during light load periods.

When the potential across the 23 regular cells drops to the predetermined low voltage (approximately 46 volts), the end cell switch automatically operates and switches the end cells into the exchange load circuit. The end cells remain in the circuit until the voltage rises to its predetermined high limit of approximately 52 volts when the end cell switch restores to normal, removing the end cells from the discharge circuit. A typical arrangement of a 26-cell battery is shown in Figure 1. The three cells on the right-hand end of the upper tier are the end cells.

The end cells are identical to the regular cells and are maintained in a fully charged condition by a manually controlled end cell rectifier which furnishes a continuous trickle charge across the three cells. If the end cells have continuously served in the discharge circuit for a period of time, they are generally recharged by means of the regular exchange charging equipment connected across the 26 cells, rather than by the small end cell rectifier, which because of its low charging rate would require considerable time to recharge the end cells.

It is the established practice in the United States to use the 8-hour discharge rate as an indication of the capacity of batteries used in automatic telephone exchanges. The ampere-hour capacity of a battery required for a particular installation is usually determined on the basis of the maximum busy hour load expected during the life of the battery, as well as by the busy hour reserve desired. The reserve is ordinarily figured on the basis of five busy hours. Thus, assuming for example a ten-year battery life, and an initial load of 40 amperes, which is estimated to increase to 70 amperes during the ten year period, the ampere-hour capacity of the battery at the 8-hour discharge rate, should be calculated on the basis of a 70-ampere load and with five busy hours reserve. This procedure must not, however, be construed as a hard and fast rule, since specific conditions may at times be such as to make it both practical and economical to install a smaller battery initially and at a later date add a second battery in multiple with the original one.

With the present day method of "full float" charging, and with correct care, the storage battery should give little or no trouble and should have a considerably longer life than was possible with the older methods of charging.

Charging Equipment

Since the full float method of charging telephone exchange batteries is practically universally used, the charging equipment must be of such design that the direct current ouput will follow the load demand up to the full rated capacity of the charging equipment. The charging equipment must also provide direct current output at a constant voltage, and maintain this voltage despite variations in the commercial power supply. If the current demand exceeds the rated output of the charging equipment, the excess load will be carried by the battery. When the load drops back to a value below the output of the charging equipment, the battery will be recharged and restored to its fully charged condition.

The type of charging equipment used in an automatic telephone exchange is contingent upon the size of the exchange, and the ultimate busy hour ampere load which may be expected, according to the fundamental plans of the exchange. In small exchanges rectifiers are most frequently used. These chargers are generally of the constant voltage type, using selenium rectifier elements. The chargers are fully automatic and have no relays or other moving parts and are amply protected against overloads. They are specially designed to maintain the direct current output at the values required to meet load conditions, and to hold the voltage of the direct current at a practically constant value. The rectifiers are available in several sizes, usually 3, 6 and 12-ampere capacities. Figure 2 shows a typical selenium dry disc rectifier—an Automatic Electric Convotrol.

While it is quite possible to operate two constant voltage rectifiers in parallel in order to carry a busy hour load which exceeds the rated capacity of one rectifier, it is generally found to be more economical to use a constant current rectifier as

Figure 2. An Automatic Electric Convotrol — a typical selenium type rectifier for small exchange use. Shown with cover removed.

the second charger. The control circuit for this method of operation is so arranged that the constant voltage charger will carry the load up to a point slightly lower than its rated capacity. When this point is reached the control circuit will operate and connect the constant current charger into the discharge circuit. The constant current charger will then carry that part of the exchange load for which its output rate has been adjusted, and the constant voltage charger will supply additional current as required, up to its rated capacity.

When the current demand falls to the capacity of the constant voltage rectifier, the control circuit will again operate and remove the constant current charger from the circuit. The constant voltage rectifier will then carry the load alone. With this arrangement the output of the constant current rectifier must be adjusted to be slightly less than the capacity rating of the constant voltage rectifier.

In larger automatic telephone exchanges motor-generators are generally used to charge the batteries. The type of motor-generator used for this purpose is a special design so constructed as to inherently maintain the direct current output voltage at a constant level, and to follow the exchange load by instantly compensating for the varying current demands of the automatic switching equipment.

Two or more motor-generators are usually supplied. The total output capacity of these machines is generally calculated on the basis of an anticipated busy hour load at some specific future date, as for example ten years from the time of the initial installation, depending upon the expected growth of the exchange. At the end of this period, if the expected growth of the exchange has materialized, another motor-generator may be added, or the existing machine may be replaced with one of larger capacity.

The motor-generators are usually furnished in different sizes as best suited for a particular exchange. For example, in an exchange engineered for a 400-ampere load, the motor-generators may comprise two 100-ampere machines and one 200-ampere machine. These machines may be operated individually or collectively as required, to carry the load. During the busy hour all machines may be run, while during other periods only the machine, or machines, needed to carry the load will be in operation. Figure 3 shows a typical arrangement of three motor-generators in a large exchange.

The motor-generator control circuit is so designed as to permit either manual or automatic control of the machine. With manual control each motor-generator may be started and stopped manually, by the operation of the starting switch associated with each motor-generator set. The switching of the generators across the exchange load, when the machines come up to speed and voltage is, however, accomplished automatically. Also, when the machines are stopped, the generators will be automatically removed from the exchange load. This automatic connecting and disconnecting of the motor-generators from the exchange load is controlled by the operation of a reverse current relay associated with each motor-generator.

With automatic control of the motor-generators, one of the machines is manually started, but the

Figure 3. Typical arrangement of three motor-generator charges for a large exchange.

remaining machines will automatically be started or stopped as load conditions demand. The sequence of operation of the machines is directed as desired, by the setting of switches on the automatic paralleling control panel.

When the manually started motor-generator reaches approximately full load a special relay in the control circuit closes its "high" contacts and starts a cycle of operations which causes the second machine to be automatically started and connected across the load. If the exchange is equipped with more than two motor-generator sets, this operation will be repeated and the third machine will automatically be cut into service when the exchange load reaches approximately 100% of the combined rated output of the two machines which are operating.

When the exchange load decreases to approximately 90% of the combined output of the first two machines, the special relay in the control circuit closes its "low" contacts and starts a cycle of operations which automatically cause the third machine to be stopped and disconnected from the load. Similarly when the load further decreases to a point of approximately 90% of the rated capacity of the manually started machine, the second machine will automatically be stopped and disconnected from the load. From there on the manually started machine will continue to operate regardless of any further decrease in the exchange load.

The a-c switches for starting the motor-generators may be either of the "across the line" type or of the "reduced voltage type". The former is usually supplied for motor-generators of less than 200-ampere capacity and the latter for motor-generators of 200-ampere or larger capacity. These switches incorporate "overload" and "no voltage" protection. Under conditions of overload current to the motors, or failure of the a-c power supply, the switches will operate and disconnect the motor from the a-c line. This, in turn, operates the reverse current relay which removes the generator from the exchange load.

Large capacity dry disc, constant voltage rectifiers are also available for use in larger exchanges. The general method of operation of these rectifiers is quite similar to that for motor-generators. The control equipment of the two types of charging machines is obviously different. Most of the rectifier control equipment is mounted on the rectifier unit, thus effecting a somewhat simpler power board.

Ringing and Tone Equipment

The type of ringing used in automatic telephone exchanges varies somewhat depending upon the class of service to be rendered. In automatic private branch exchanges, the ringing is usually of the single frequency type, since party line service is seldom given. If occasionally two-party service should be desired, this may be rendered by using divided ringing, over each side of the line to ground.

In smaller public exchanges, particularly those serving rural areas, code ringing of party lines is often used. Code ringing may be either divided, over each side of the line to ground, or bridged across the line, depending upon local conditions. With the equipment arranged for ten-party divided ringing, the two-party ringing will be full selective while the four-party and up to the ten-party ringing will be semi-selective.

Harmonic ringing of party lines is extensively used in the larger exchanges, and is also quite often used in smaller exchanges where full selective ringing is desired. This type of ringing provides ten-party full selective ringing on a divided ringing basis of five parties over each side of the line to ground. If, due to inductive interference, divided ringing can not be employed, ten-party, one- and two-ring, semi-selective harmonic bridged ringing may be used. The harmonic frequencies may be either the multiple type ($16\frac{2}{3}$, $33\frac{1}{3}$, 50, $66\frac{2}{3}$ and 25 cycles), the non-multiple type (20, 30, 42, 54, and 66 cycles) or of the decimonic type (20, 30, 45, 50 and 60 cycles) as required for each specific installation.

In some exchanges "superimposed" ringing is used. This type of ringing uses single frequency ringing current (generally 20 cycles), but requires negative and positive superimposing batteries and two tripping (ring cut-off) batteries. Superimposed ringing provides full selective ringing on four-party lines, and semi-selective, one- and two-ring, on eight-party lines. Each telephone on such lines is equipped with a cold cathode electronic tube. These are so connected in series with the biased ringers that they will permit only one ringer on a four-party line (or two ringers on an eight-party line) to operate at one time, depending upon the polarity of the superimposing battery and the side of the line to which the ringers are connected.

The generating equipment used for producing the alternating ringing current may be either of the vibrator type, or of the rotary type, depending upon the size of the particular exchange, and the preference of the purchaser. Duplicate sets of ringing equipment are usually provided, and the equipment is so arranged as to automatically switch from one set to the other in case of failure of the set being used. If rotary ringing machines are used, it is customary to operate one machine direct from the commercial power supply and the other machine from the exchange battery.

In addition to the equipment required for generating the alternating ringing current, there is also need for such related equipment as interrupters and tone generators.

Ringing interrupters are used to provide the "ringing" and "silent" periods of the ringing cycle. The purpose of this arrangement is to obtain the fullest utilization of the capacity of the ringing machines by distributing the ringing load, over the ringing cycle, to several different ringing groups. Thus, on the basis of a five-second ringing cycle, with one second ringing and four seconds silence, one of five ringing groups would have ringing current available each second of the five-second ringing cycle.

The interrupter also furnishes pulses for other uses, such as busy tone, flash busy to toll operators, time pulses, etc. In cases of exchanges using code ringing, the code pulses are also produced by the interrupter.

In exchanges using rotary ringing machines the ringing interrupter may be incorporated as a part of the ringing machine. Similarly the commutator or tone generator used for producing dial and busy tones may also be incorporated into the ringing machine. However, from the viewpoint of operation and maintenance, it is often found that a more desirable arrangement is to provide separate rotary interrupter machines and separate rotary tone generators.

In smaller exchanges the interrupter and tone equipments are most frequently of the relay type. This equipment, like the ringing equipment, is usually furnished in duplicate, with switching relays for the automatic transfer of the load from one set to the other in case of failure of the set being used.

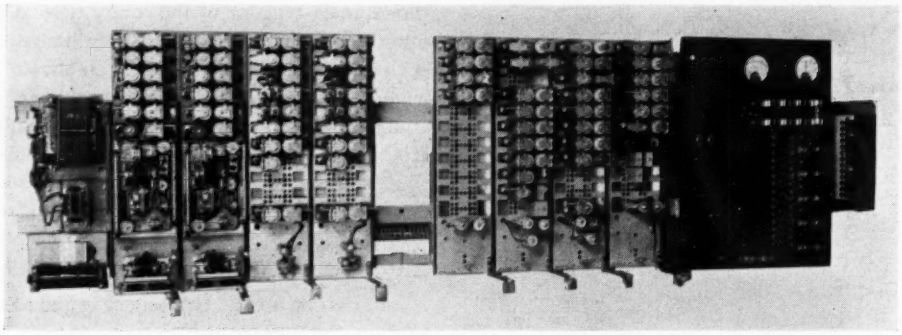


Figure 4. A "power shelf" as used in small automatic exchanges.

Power Control Equipment

The power control and supervisory equipment in an automatic telephone exchange form an important link in the various items comprising the power plant. This equipment insures smooth and efficient operation, not only of the power equipment itself, but also of the exchange as a whole, by means of well planned supervisory functions.

In the smaller automatic exchanges the power control and supervisory equipment is mounted on power shelves, which in turn are mounted on frames, together with the regular exchange switching equipment. The various apparatus units are mounted on standard "jack-in" type bases which permit easy mounting and removing of the units, without the necessity of unsoldering any connections. At the end of the shelf is mounted a power panel equipped with voltmeter, ammeter and the necessary bus-bars and fuses for distributing the power leads to the various switching units in the exchange. A typical power shelf is shown in Figure 4.

Apparatus units mounted on the power shelves generally include the following items:

Vibrator type ringing machine (for code ringing exchanges only).
Ringing interrupters.
Busy, dial and discriminating tone equipment.
Ringing relays.
Ringing equipment transfer relays.
Power supervisory relay equipment.
Alarm sending equipment.
Timer equipment.

For local supervision, a key and lamp panel is provided, mounted adjacent to the power panel on the power shelf.

For remote supervision, in the case of unattended exchanges, the alarm sending equipment provides for the automatic transmission of alarms to the control office. The operator at the control office, upon receiving an alarm, dials an alarm checking number in order to ascertain the nature of the alarm, whether "emergency" or "non-danger", as indicated to her by identifying tones.

In addition to the power shelf, there is also furnished a power frame for mounting the rectifier, counter cell control equipment and rectifier cut-in relays for use when more than one rectifier is used.

When harmonic ringing is used in small exchanges the duplicate sets of harmonic vibrators are mounted on a separate shelf together with the associated frequency meter.

In an automatic telephone exchange which uses motor-generators for charging the storage batteries, the power control, supervisory and power distributing equipment is built into a suitable power board designed to meet the specific requirements of that exchange. Such a power board consists of a number of panels upon which are mounted the various control units. The size and design of the power board depends upon such factors as: the initial and

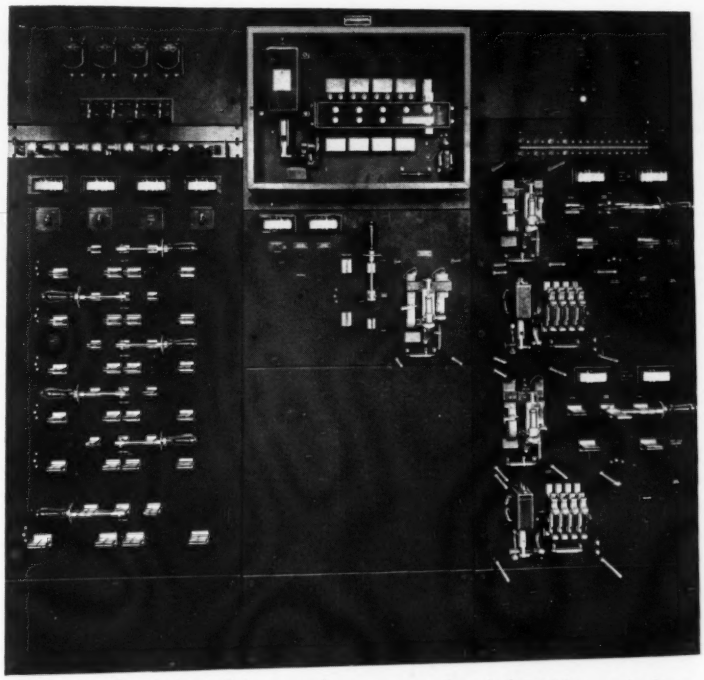


Figure 5. Front view of large exchange power board (cartridge and alarm fuses removed).

ultimate number of subscribers' lines for which the exchange is planned; the initial and ultimate number of motor-generators; the type of ringing equipment to be used; and other variables which must be considered in connection with each particular installation. Often all or part of the power and ringing equipment may be located in the basement of the telephone building, while the supervisory and power distributing panels are located in the automatic switch room. These and other such varying requirements affect to some extent the design and arrangement of the power board.

Figure 5 shows the front equipment of a typical large exchange power board. Separate fuse distributing, supervisory and ringing machine control panels are used on this board. This particular power board is designed for a capacity of 1400 amperes. It is equipped initially for two 400-ampere and one 200-ampere motor-generators, with provision for the future addition of one 400-ampere motor-generator. The upper unit of the left-hand panel is the automatic paralleling equipment for four motor-generators. Below this unit are some associated relays and the distributing and discharge fuse and switch panel with associated voltmeters and ammeters. The upper unit of the center panel is the end cell switch, which has a capacity of 1600 amperes.

The control equipment for the 200-ampere motor-generator is shown below the end cell switch. Directly below is a blank panel reserved for the future 400-ampere motor-generator control equipment. The upper unit of the right hand panel is the control switch for the end cell rectifier. The two bottom units on this panel are the control equipments for two 400-ampere motor-generators. Figure 6 is a rear view of the same power board, and shows the bus-bar arrangements for interconnecting the various units and for connecting to the storage battery.

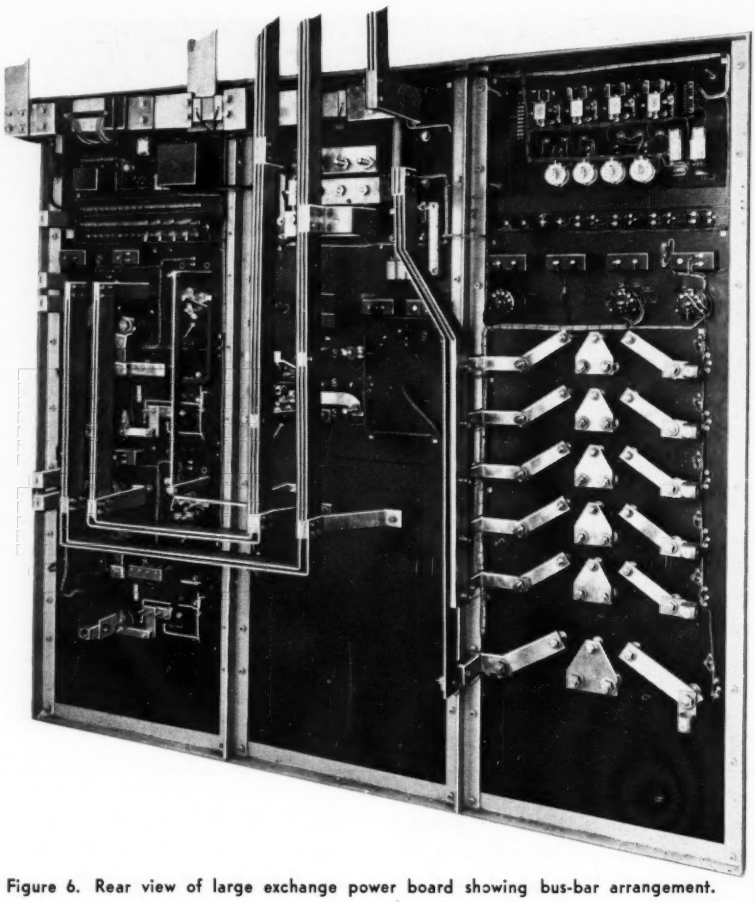


Figure 6. Rear view of large exchange power board showing bus-bar arrangement.

Figure 7 shows a detail view of the 400-ampere motor-generator control equipment of Figure 5. The reverse current relay for connecting and disconnecting the generator to and from the exchange load is shown in the upper left hand corner and the associated contactor is shown in the lower left hand corner. On the right side are shown the voltmeter and ammeter and directly below are the charging switch and fuse and the field rheostat.

Figure 8 shows a typical power board for a medium size exchange using harmonic ringing. The board is equipped initially for one motor-generator with provision for the future addition of a second. The upper unit of the left hand panel is the automatic paralleling equipment for two motor-generators. Since this installation initially is equipped with only one motor-generator, this unit will serve only for the manual control of the motor-generator until the second motor-generator is installed and the automatic paralleling of the motor-generators becomes operative.

Directly below the paralleling panel is the supervisory fuse panel and the harmonic ringing equipment with duplicate sets of vibrator type converters. Also shown are the ringing interrupter relays, tone generating equipment and the exchange supervisory relays.

The upper unit of the right-hand panel is the

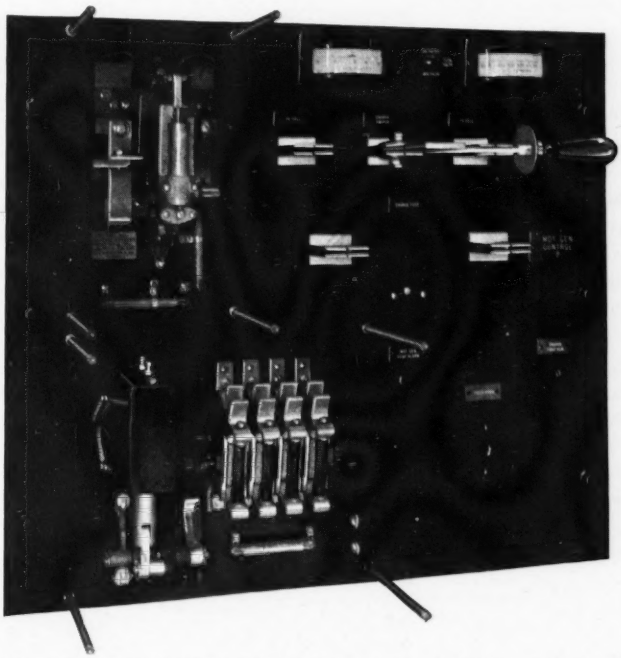


Figure 7. View of 400-ampere motor-generator control equipment of Figure 5.

exchange distributing fuse panel. Directly below is the discharge panel with voltmeter and ammeter. Below this is the motor-generator control equipment and a blank panel reserved for the control equipment for the future motor-generator. The bottom unit is the end cell switch with associated "low" and "high" voltage test keys and alarm signal lamp.

Emergency Power Equipment

The necessity for adequate emergency power, to insure continuity of service in case of prolonged failure of the commercial power supply, is increasingly becoming an important factor in the design of modern telephone exchanges. Stationery emergency power plants are almost always provided in both medium and large size exchanges, while portable sets are available for small, unattended exchanges.

The stationery type engine-generator set generally consist of a gasoline or Diesel powered engine, connected to an alternator which generates current of the same voltage, phase and cycle characteristics as the commercial power. The power output of the generator should be sufficient to operate all of the equipment essential to mantaining continuous telephone service during the emergency. This includes power for operating the motor-generators, rectifiers, ringing machines, carrier equipment, etc., as well as power for such appliances and building lighting which may be considered to be essential during the emergency.

The preferred method is to arrange the engine-generator set for automatic starting in the event of a commercial power failure, although it may, if desired, be arranged for manual starting.

Associated with the commercial power supply and the engine-generator is a magnetically operated double throw transfer switch. The circuits supplying alternating current to the essential services which are to be kept operating are connected to the center point of the double throw switch which

is normally closed to the position to which the commercial power is connected. In the event of power failure the engine-generator immediately starts and the transfer switch operates to the opposite position thus opening the connection to the commercial power supply and connecting the emergency power supply to the essential circuits. The other operations, such as starting and operating the motor-generators and a-c operated ringing machines are not automatically transferred to the emergency power supply. These machines must be manually connected to the emergency power supply and started one by one, allowing time for each machine to start and come up to speed before starting the next one.

The same procedure is followed in order to revert to normal operation when the commercial power is restored. The engine-generator is automatically stopped, the transfer switch operates and connects the essential service circuits to the commercial current supply while the motor-generators are manually switch back to the same source.

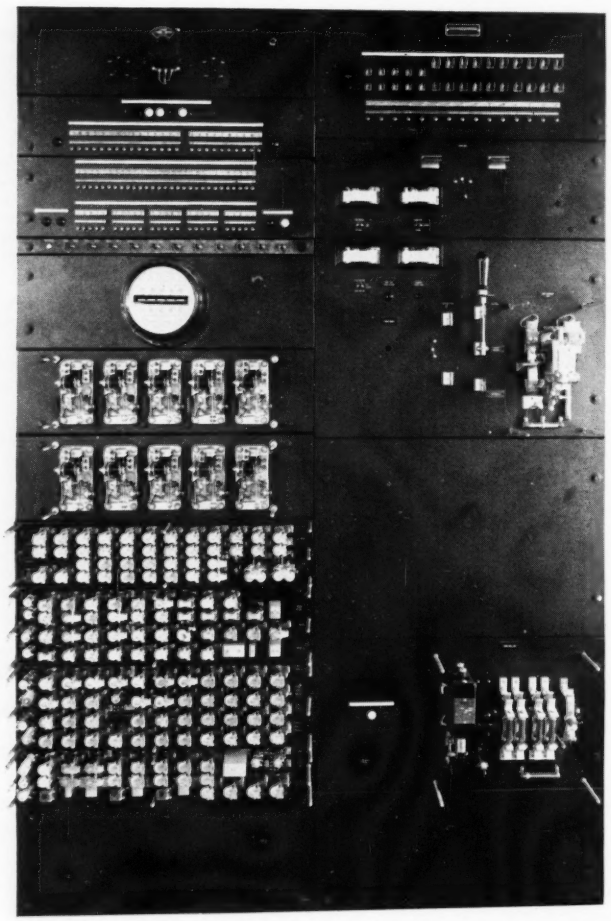


Figure 8. Typical power board for medium sized exchange using harmonic ringing (fuses and apparatus covers removed).

The installation of an emergency unit such as just described makes it possible to reduce somewhat the size of the battery since a two or three busy-hour reserve is generally considered adequate in place of the customary five busy-hour reserve.

The portable sets, as used in connection with small, unattended exchanges, are usually of smaller output capacities and are manually controlled. They may be obtained with either a-c or d-c generators, for operating the exchange charging equipment or for direct charging of the battery, as desired.

Conclusion

While the foregoing generally describes the components of modern power plants in Strowger Automatic exchanges, the particular arrangements shown must be regarded as merely typical. As is the case with Strowger Automatic equipment itself, the components are designed and built to a reasonable degree of standardization, but in arrangement and combination they may vary widely from one exchange to another, each power plant being "tailor-made" to meet the specific requirements of the individual exchange.

THE TYPE 48 COMMUNITY AUTOMATIC EXCHANGE

By C. CHRISTENSEN

SYNOPSIS: ***Need for small capacity automatic switchboards with toll supervision — the Type 48 C-A-X — capacity—general design features— range of services — line circuits — ringing codes — toll supervision — physical arrangement of units.***

THERE are many hundreds of rural telephone exchanges of 20 lines or less operated by the Independent companies of the United States, plus many hundreds more of 20 to 40 lines. Manual exchanges within these ranges have long been a major financial problem to operating companies because of the relatively small revenue received, and the high cost of operation particularly if prompt service is to be given on a 24-hour basis.

Automatic Electric Company recognized this problem many years ago with the introduction of the Type 36A1 C-A-X, a 19-line automatic switchboard[1]. However, with the growing use of intertoll dialing and the development of new components and techniques, it became desirable to design new automatic switchboards of small line capacity which would include modern facilities for toll dialing supervision and features of durability which would improve service and minimize the need for maintenance. The Types 48A and 48B C-A-X's, having 20-line and 40-line capacities, respectively, have been designed to meet these requirements.

General Description

The Type 48 C-A-X is a 48-volt, common battery, fully automatic telephone switchboard designed for operation on an unattended basis. Toll calls are supervised by the operator at an attended exchange to which the C-A-X is connected, while local calls are completed by automatic switching equipment.

In addition to providing new service features, the Type 48 C-A-X makes use of important new components, including Types 57 and 58 twin contact relays and the Type 45 rotary switch[2] for line finders and connectors.

The finder-connector links, line relay groups (10 per group), and trunk relay groups, as well as the ringing converters, ringing interrupter, and tone units, are mounted on separate mounting plate units. All equipment on each mounting plate is wired to a unit terminal block which permits the easy addition of lines, trunks, and links to a partially equipped switchboard, if and when required, as illustrated in Figures 1 and 2.

Since the circuits follow established and proved principles they are not included in this description. However, the following will give the reader a broad understanding of the design features of these switchboards and the field of service they are intended to cover.

Outline of Principal Features

The principal features of the Type 48 C-A-X include the following:

1. Use of Type 45 Rotary Switches as linefinders and connectors.

2. Use of Types 57 and 58 relays with twin contacts and heavy duty, long-life bearings.

3. Serves subscribers' lines having up to 1,200 ohms loop resistance (not including telephone) with a minimum line leakage of 10,000 ohms.

1. The Type 36A1 Community Automatic Exchange, By C. E. Lomax. *The Strowger Technical Journal,* December, 1937.

2. The Type 45 Rotary Switch, By R. L. Huffman, *The Automatic Electric Technical Journal,* July, 1948.

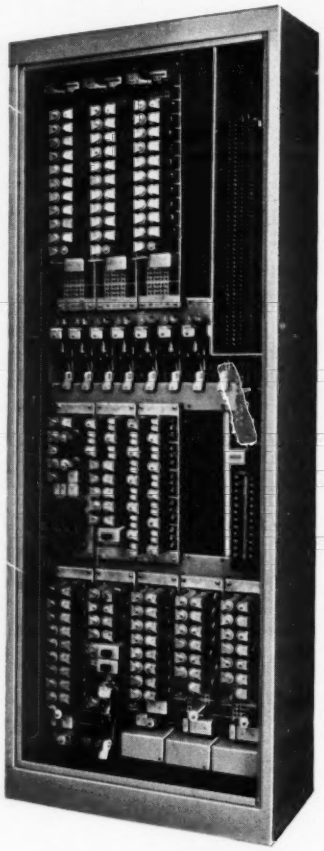


Figure 1. Type 48A, 20-line C-A-X, front door removed.

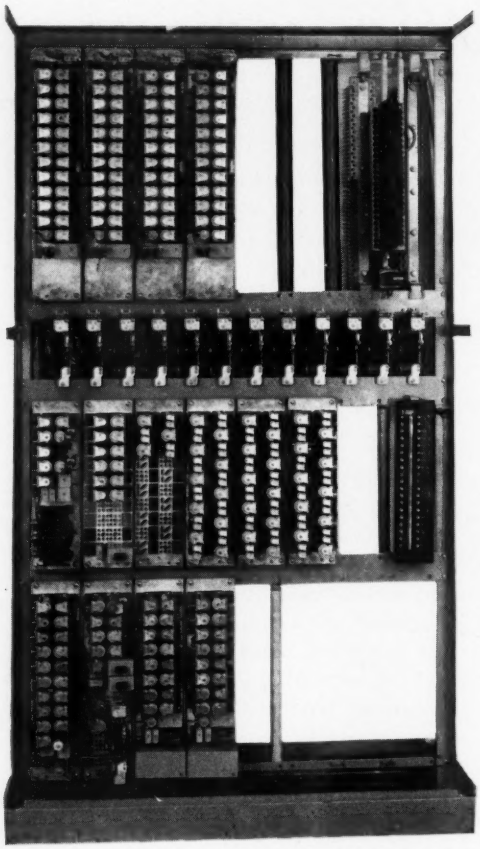


Figure 2. Type 48B, 40-line C-A-X, front and rear doors and cover removed.

4. Simple ground return line adapters available to permit connecting a few grounded lines to the switchboard.

5. Employs ten-party connectors with bridged or divided ringing.

6. 100% line lockout.

7. Duplicate ringing converters with automatic transfer.

8. Relay type code ringing interrupter, providing 10 codes and reverting call timing.

9. Dial, busy, reverting call, and "all-links busy" tones, and flash busy toll supervision.

10. Peg count, all-trunk-busy, or overflow meter.

Capacity

The two switchboards are wired for ultimate capacity in accordance with the following:

Type	*Lines*	*Links*	*Trunks*	*Trunk Groups*
48A	20	4	3	2
48B	40	6	6	3

and are available with choice of initial equipment in accordance with the following:

Type	*Lines*	*Links*	*Trunks*	*Trunk Groups*	*Maximum Trunks per Group*
48A	10 or 20	2, 3, or 4	as required	1 or 2	3
48B	20, 30, or 40	4, 5, or 6	as required	1, 2, or 3	3

Services

The following classes of service are available:
Single party
Two party—full selective
Five party—bridged code ringing
Ten party—bridged code ringing
Ten party—divided code ringing
Single party postpay paystation

Subscriber Lines

Both C-A-X's will serve metallic lines, with a loop resistance from 0-1200 ohms, and with minimum line leakage of 10,000 ohms. Each line may have up to 10 high impedance or 5 low impedance bridged ringers, or 5 low impedance or high impedance ringers on each side of the line for divided ringing.

Subscribers' Line Circuits

The line relay circuit in each switchboard consists of three relays, providing 100% lockout. The lock-out feature guards against the unnecessary holding of a connecting link by a line which either has an external fault or has inadvertently been made busy by a subscriber. Such lines are automatically disconnected or "locked out" from the switchboard after a pre-determined length of time; when this happens the link is released for use on other calls. Service is automatically restored to a locked out line as soon as the condition which is holding the line locked out is cleared.

The line lock-out equipment also provides for the release of links during reverting call conversations. On such calls talking current is supplied to both stations through the line relay.

Numbering

Directory numbers of subscriber stations consist of three digits. The first two digits select the line; the third digit selects the ringing code and the side of the line to which ringing current is to be applied. Directory numbers for local calls start with "2" or "3" for the Type 48A C-A-X, and "2", "3", "4", or "5" for the Type 48B. A trunk group is normally reached by a single digit.

Directory Numbers Available

211-200 First Ten Lines
311-300 Second Ten Lines
411-400 Third Ten Lines—Type 48B only
511-500 Fourth Ten Lines—Type 48B only
7 Alarm Checking Number
8 Automatic-to-Automatic Trunks — Type 48B only
9 Automatic-to-Automatic Trunks
0 Automatic-to-Manual Trunks

Ringing Codes

The ringing codes available are shown in the following tabulation:

Digit Dialed	*Ringing*	*Side of Line*
1	1 Long	Neg.
2	2 Short	Pos.
3	4 Short	Neg.
4	1 Long, 1 Short	Pos.
5	1 Long, 2 Short	Neg.
6	2 Short, 1 Long, 1 Short	Pos.
7	2 Long	Neg.
8	2 Long, 1 Short	Pos.
9	1 Long, 3 Short	Neg.
0	2 Short, 1 Long	Pos.

Paystations

One or two of the lines may be used for postpay or semi-postpay paystation service and are arranged to give an identifying tone on calls to the toll operator. On local calls, coin control in semi-postpay paystations is by battery reversal to the calling station when the call is answered. On toll calls, operation is postpay. A paystation "splash" tone, provided on either direct or tandem trunks, is momentarily heard by the operator when she answers. The operator can bring the tone back for verification by momentarily removing the plug from the jack.

Toll Supervision

The following toll supervision features are available on incoming calls from the toll operator.

(a) A "stop dial" signal is extended to the operator until the linefinder has extended the call to an idle connector.

(b) Combination flash and tone busy at 60 ipm is provided when the called line is busy.

(c) "Off hook" supervision is given when the called party answers; "on hook" supervision is given when the called party hangs up.

(d) The release of the call is under control of the toll operator; thus, during a call, the called party may signal the toll operator by flashing without releasing the equipment.

On outgoing calls to the toll operator via CLR trunks, provision is made for the toll operator to receive a splash of tone on a call from a paystation. On all calls the calling party can flash the operator during the call. Release of the trunk is under control of the last party to hang up.

Reverting Calls

Subscribers on party lines make reverting calls by dialing the directory number of the called station. This brings in busy tone, indicating that the handset should be restored in order to start the ringing of the called station.

On bridged ringing lines, the ringers of all stations will operate in response to the called station ringing code. On divided ringing lines, the ringers of only those stations connected to the same side of the line as the called station will operate.

The called party, upon answering, will receive a reverting call tone which indicates that he must hold the connection until the calling party answers.

Alarm Checking

Alarm checking is accomplished from the distant office by the operator dialing the digit "7" on any one of the local links. If conditions at the exchange are normal, the operator will receive an audible signal of 2 rings. The operator will receive no tone when any one of the following unstandard conditions exists:

Fuse blown
Heat coil operated
Charger failure
Ringing machine not operating
Ringing interrupter not operating

The operator automatically checks for dial tone each time she makes a call. She can also establish busy line conditions to test the busy tone.

Call Allotter

The allotter in both C-A-X's distributes calls over the links by assigning a different link for each succeeding call, provided an idle link is available. It assigns a second link if the first one assigned to a call fails to find the calling line within a timed interval. The allotter not only distributes traffic evenly over all links, but also prevents any faulty link from putting the entire board out of service. In the event that an idle link is not available, the allotter will return "all links busy" tone (at 120 ipm) to the calling station.

Trunk Services

Three single-digit two-way trunks are provided in the Type 48A C-A-X in addition to the regular twenty line terminals. These trunks can be wired in one or two groups, in accordance with the following assignments:

"0" group, 3 trunks;
or
"0" group, 2 trunks, and "9" group, 1 trunk;
or
"0" group, 1 trunk, and "9" group, 2 trunks.

Two sets of three single-digit trunks are provided in the Type 48B C-A-X in addition to the regular 40-line terminals. These six trunks can be wired in two or three groups, in accordance with the following assignments:

"0" group, 3 trunks, and "9" group, 3 trunks;
or
"0" group, 3 trunks, "9" group, 2 trunks, and "8" group, 1 trunk;
or
"0" group, 3 trunks, "9" group, 1 trunk, and "8" group, 2 trunks.

Although the above provisions are ample for most small exchanges, both the 48A and 48B C-A-X's may be arranged for serving additional two-way trunks on a two-digit basis. Such trunks, however, must be connected to regular line terminals in the second group of subscriber lines, and such use correspondingly reduces the subscriber line capacity. Trunk hunting is available

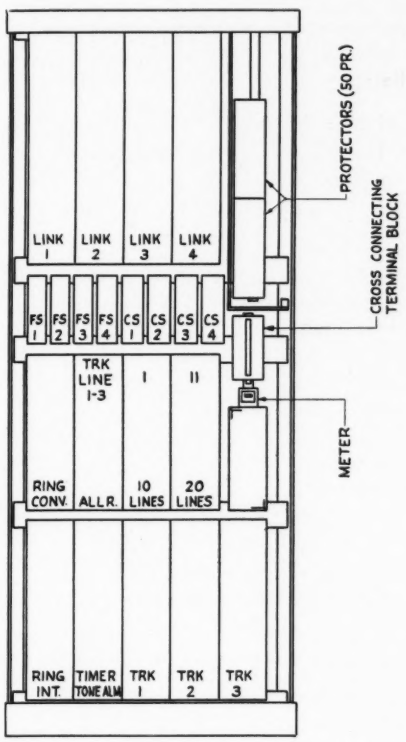


Figure 3. Equipment layout of the Type 48A C-A-X.

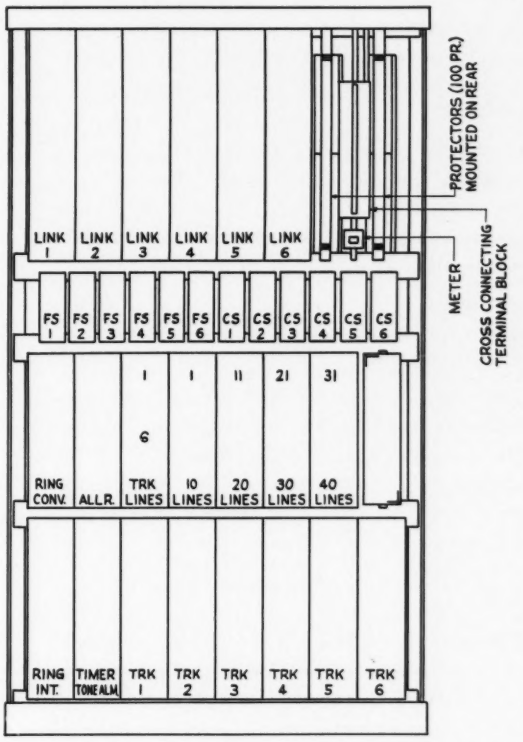


Figure 4. Equipment layout of the Type 48B C-A-X.

for such trunks if they are grouped on consecutive lines.

All trunks are arranged for simplex or composite dialing—automatic-to-manual ("0" trunks) "ring down" signaling with "high-low" supervision, or automatic-to-automatic ("0" trunks) via a tandem office to the toll operator; automatic-to-automatic ("9" and "8" trunks) "positive and negative battery" dialing and supervision, or automatic-to-manual ("9" and "8" trunks) "ring down" signaling with "high-low" supervision.

Mounting

The apparatus for each switchboard is mounted on a single-sided framework which is enclosed in a dust excluding metal cabinet. It consists of protectors and cross connecting terminal block (main distributing frame), finder-connector links and link relay equipment, ringing converters, relay-type allotter, line relay equipment, ringing interrupter, timer tone alarm, and trunk relays.

The finder-connector link relay equipment is mounted across the top of the switchboard, and directly below it are mounted the finder and connector rotary switches. Below these are the ringing converters, allotter, and line relay equipment. The ringing interrupter, timer tone alarm, and trunk relay equipment are mounted across the bottom of the switchboard. Equipment units making up the switchboard are well marked and are readily identified, as illustrated in Figures 3 and 4.

A gate-arranged shelf for mounting on the rear of the switchboard, inside the cover, is also available. This shelf will mount composite coil equip-

ment, grounded line adapters, or additional trunk circuits as required. The Type 48A C-A-X has space for a four-position shelf, while the Type 48B can mount a five-position shelf.

Dimensions

It will be noted from the foregoing that all switchboard apparatus is arranged for easy accessibility. Notwithstanding this, both units are exceedingly compact, requiring very little space, as shown by the following table of dimensions:

Switchboard	*Width*	*Depth*	*Height*
Type 48A (20 lines)	2′-3″	1′-4″	5′-8⅝″
Type 48B (40 lines)	3′-4″	1′-4″	5′-8⅝″

The above dimensions do not include space occupied by the rack for the battery and charger which may be mounted independently of, or adjacent to, the switchboard. The battery and charger rack is 2′-0″ wide and 1′-4″ deep as illustrated in Figure 5.

Power

The battery consists of 23 cells of 50-ampere hour capacity and is charged by a three ampere Type 47 constant voltage battery charger (Convotrol)[3], arranged to operate from 115/230 volt, 60 cycle, single phase, a-c.

Conclusion

Because these switchboards are not expansible beyond their respective 20-line and 40-line capacities, they provide the maximum in simplicity, compactness and ready mobility. They are therefore economically adapted not only to small exchanges where growth is expected to be limited, but also to the needs of those companies which operate a number of small exchanges. Such companies often find it advantageous to move an outgrown switchboard to another exchange within its capacity and replace it with a larger unit rather than to go to the expense of providing expansion facilities which may not be needed within its normal lifetime.

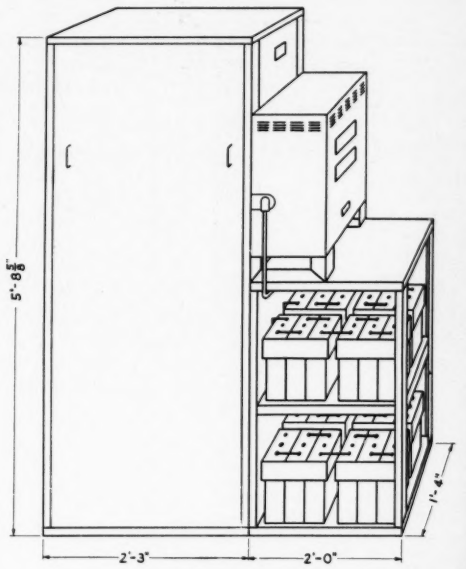


Figure 5. Typical arrangement for complete Type 48A C-A-X installation, showing cover, battery, and charger rack.

Furthermore, with the availability of a cross-connecting field (between the outside cables which terminate on protectors and the switching equipment which terminates on a terminal block) it is possible to assign two or more partially loaded lines to one connector terminal, thereby loading line equipment to the ultimate of ten parties per line terminal.

Finally, these switchboards are, as indicated previously, especially designed to minimize the need for maintenance, through the use of components which have been demonstrated by long field tests to be exceedingly durable and dependable.

3. The Convotrol, By O. D. Grandstaff. *The Automatic Electrical Technical Journal,* July, 1948.